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The Frequency Compensation of Moving-Iron Voltmeters

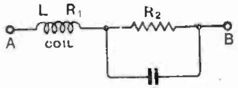

Fig. 1.

SOFT iron voltmeters have a relatively large inductance, which causes an increase of impedance, and consequent decrease of current, with increasing frequency. One method of compensating for this is to shunt the series swamping resistance with a condenser, as shown in Fig. 1 which is reproduced from Fig. 226 on page 288 of "Electrical Measuring Instruments" by Drysdale and Jolley. It is there correctly explained that the impedance of the coil is $R_1 + j\omega L$, that of the shunted resistance $R_2(1 - j\omega CR_2)/(1 + \omega^2C^2R_2{}^2)$, and the total impedance therefore

$$R_1 + \frac{R_2}{1 + \omega^2C^2R_2{}^2} + j\omega\left(L - \frac{CR_2{}^2}{1 + \omega^2C^2R_2{}^2}\right).$$

It is then stated that "in practice ωCR_2 is small compared with unity, and therefore the total impedance may be written—

$$R_1 + R_2 + j\omega(L - CR_2{}^2)$$

Hence if $C = L/R_2{}^2$ we have compensation for all working frequencies."

Drysdale and Jolley then say: "As an example, let us consider a soft iron voltmeter taking 0.05 ampere at 120 volts, and having an inductance of 0.5 henry. The total resistance of the circuit will be 2,400 ohms, of which one-tenth, or 240 ohms, may be in the copper solenoid, and the remaining 2,160 ohms in the external resistance R_2."

"Then $C = \frac{L}{R_2{}^2}$ farads $= \frac{10^6L}{R_2{}^2}$ microfarads

or $C = \frac{0.5 \times 10^6}{2160^2} = 0.107$ microfarads."

"In practice the capacity would be greater for complete compensation, owing to the demagnetising effects of eddy currents."

Let us now look into the above example a little more closely. The reactance of the coil at a frequency of 50 c/s is $2\pi \,.\, 50 \,.\, 0.5$, i.e. 157.1 ohms, and, without the condenser, the impedance Z at a frequency of 50 is 1.00215 times the resistance; the error would therefore be 0.215 per cent. With the condenser of the calculated value, viz. 0.107 μF, $\omega CR_2 = 2\pi \,.\, 50 \,.\, 0.107 \,.\, 2160/10^6 = 0.0727$ and $\omega^2C^2R_2{}^2 = 0.00528$, which is certainly small compared with unity, but, be it noted, *more than twice as great as the error that we are trying to correct.* For the total impedance we now have

$$\begin{aligned} Z &= R_1 + \frac{R_2}{1 + \omega^2C^2R_2{}^2} + j\omega\left(L - \frac{CR_2{}^2}{1 + \omega^2C^2R_2{}^2}\right) \\ &= 240 + \frac{2160}{1.0053} + j\left(157.1 - \frac{0.0727 \times 2160}{1.0053}\right) \\ &= 240 + 2148.6 + j\left(157.1 - \frac{157.1}{1.0053}\right) \\ &= 2388.6 + j\,0.83. \end{aligned}$$

The instrument is thus practically non-inductive but its impedance has been reduced from 2,400 to 2,388.6 ohms, i.e. 11.4 ohms. And the error will now be 0.475 per cent.

Hence the alleged compensation has more then doubled the error that it was supposed to compensate.

An accurate determination shows that the correct value of the capacitance is 0.04176μF, which is little more than a third of the value given by the Drysdale and Jolley formula.

To show that this is no exceptional case we shall now consider another example taken from a Degree Examination paper which first drew our attention to the fallacy. The moving-iron voltmeter for 150 volts had a coil resistance of 400 ohms and an external resistance of 2,600 ohms, making a total of 3,000 ohms; the inductance was 0.75 henry; the candidates were asked to find the error at a frequency of 100 and to calculate the capacitance of the condenser necessary to eliminate this frequency error.

It will have been noticed that the frequency does not appear in the Drysdale and Jolley formula.

Without the condenser, $\omega L = 2\pi \,.\, 100 \,.\, 0.75 = 471$, $Z = \sqrt{3{,}000^2 + 471^2} = 3036.6$, an increase of 1.22 per cent. which would therefore be the error. The capacitance required according to the above formula is

$$C = \frac{L}{R_2^2} = \frac{0.75 \times 10^6}{2{,}600^2} = 0.111\ \mu\text{F}.$$

With a compensating condenser of this capacitance

$$\omega C R_2 = 2\pi \,.\, 100 \,.\, 0.11 \,.\, 2{,}600/10^6 = 0.18$$

and $\omega^2 C^2 R_2^2 = 0.032$

$$Z = 400 + \frac{2600}{1.032} + j\left(471 - \frac{471}{1.032}\right)$$
$$= 400 + 2519.4 + j\,15$$

The last term is practically negligible, but the impedance has been reduced from 3,000 to 2,919.4 ohms, i.e. a reduction of 2.7 per cent.

Hence the addition of the compensating condenser has increased the error from 1.2 to 2.7 per cent.

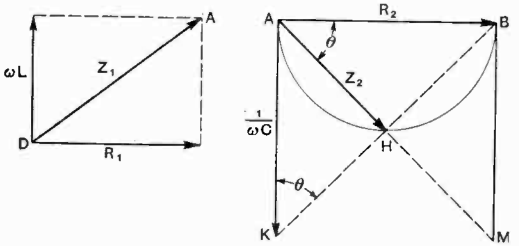

Fig. 2.

The above method of calculating the necessary capacitance is evidently quite inadmissible; without the condenser the voltmeter reads low on alternating current, but with the condenser in both examples it reads much too high, showing that a much smaller capacitance is required. The actual value required to give compensation can, however, be determined as follows.

In Fig. 2 the resultant impedance of R_1 and ωL is the vector DA; the joint impedance of R_2 and $\frac{1}{\omega C}$ in parallel is the vector AH perpendicular to BK. If the value of C is varied, the point H moves on the semicircle on AB.

It may be noted that $\tan\theta = \frac{BH}{AH} = \frac{AB}{AK} = \omega C R_2$ and that if AH be produced to meet the vertical through B at the point M, $BM = R_2 \tan\theta = \omega C R_2^2$.

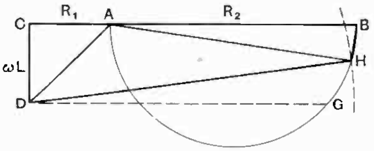

Fig. 3.

The impedance of the coil in series with the swamping resistance and condenser in parallel is simply the resultant of DA and AH as shown in Fig. 3 where the resultant is obviously DH. If the instrument is correctly compensated DH is equal to CB, hence with centre D and radius CB one draws an arc cutting the semicircle at H; then

$$C = \frac{BH}{AH} \cdot \frac{1}{\omega R_2}$$

An accurate graphical construction for the second example considered above gives $C = 0.044\ \mu$F instead of $0.111\ \mu$F. Hence in this case the Drysdale and Jolley formula gives a capacitance 2.5 times the correct value. The reason for this big discrepancy can be clearly seen in Fig. 3, since their formula gives approximately a non-reactive resultant, that is to say, a horizontal resultant, viz. the line DG, which obviously corresponds to about 2.5 times the capacitance, and is less than CB.

Although, if done carefully and to a large scale, the graphical method is probably the most convenient and accurate, the value of the capacitance can be calculated as follows.

In Fig. 4 $\tan\alpha = \frac{X}{R_1 + R_2/2} = z$ say.

$DH^2 = DP^2 + R_2^2/4 - 2DP\,\frac{R_2}{2}\cos\beta$ and this must equal $(R_1 + R_2)^2$ if the compensation is correct. Therefore

$$R_1^2 + R_2^2 + 2R_1R_2$$
$$= \left(R_1 + \frac{R_2}{2}\right)^2 + X^2 + \frac{R_2^2}{4}$$
$$- R_2\sqrt{\left(R_1 + \frac{R_2}{2}\right)^2 + X^2}\cos\beta$$

and

$$\cos\beta = -\frac{\left(R_1 + \dfrac{R_2}{2}\right) - \dfrac{X^2}{R_2}}{\sqrt{\left(R_1 + \dfrac{R_2}{2}\right)^2 + X^2}} = -\frac{1 - z\dfrac{X}{R_2}}{\sqrt{1 + z^2}}.$$

Since $\alpha + \beta + \gamma = 180°$, $\cos\beta = -\cos(\alpha + \gamma)$.

In the two examples the values of z^2 were 0.0773 and 0.0142, and one can therefore, as an approximation, put

$1/\sqrt{1 + z^2} = 1 - z^2/2$ and we thus have

$$\begin{aligned}\cos(\alpha + \gamma) &= \left(1 - z\frac{X}{R_2}\right)\left(1 - \frac{z^2}{2}\right)\\ &= 1 - z\frac{X}{R_2} - \frac{z^2}{2} \text{ approximately}\\ &= 1 - z^2\left(\frac{R_1 + R_2}{R_2}\right)\end{aligned}$$

The angles α and $\alpha + \gamma$ can thus be determined from trigonometrical tables, and

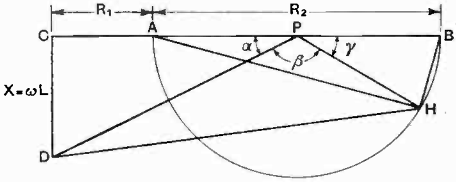

Fig. 4.

having thus found γ we see from Fig. 4 that the angle $BAH = \gamma/2$, so that

$$\frac{BH}{AH} = \tan\gamma/2. \quad \text{Hence } C = \frac{\tan\gamma/2}{\omega R_2}.$$

Applying this to the second example, we have

$$\tan\alpha = z = \frac{471}{400 + 1300} = 0.278$$

$$\text{and } z^2 = 0.077,$$

$$\therefore \cos(\alpha + \gamma) = 1 - 0.077\frac{3000}{2600}$$

$$= 1 - 0.089 = 0.911$$

Hence $\alpha = 15° 32'$ and $\alpha + \gamma = 24° 22'$, so that $\gamma = 8° 50'$, $\tan\gamma/2 = \tan 4° 25' = 0.077$

$$\text{and } C = \frac{0.077}{200 \,.\, \pi \,.\, 2600} = 0.047 \times 10^{-6}$$

or $0.047\ \mu F$.

This is near enough to the accurate value of $0.044\ \mu F$ for most practical purposes. The same method of calculation applied to the first example gives a capacitance of $0.0437\ \mu F$, the accurate value being $0.0418\ \mu F$.

Strictly speaking, the inductance of the voltmeter varies with its reading, but this effect will be very small, so that the compensation at a given frequency can only be absolutely correct at one point of the scale.

Postscript

Since writing the foregoing article we have discovered that the fallacy was pointed out by Mr. R. O. Carter in 1932*. He neglected the resistance R_1 of the coil, but with this simplification was able to show that the correct value of the capacitance was very nearly $(\sqrt{2} - 1)\dfrac{L}{R_2^2}$ that is $0.414\ L/R_2^2$. It is interesting to note that in our two examples the correct value was 0.39 and 0.396 L/R_2^2.

Mr. Carter made the interesting statement that instrument designers frequently employ a capacitance of about half the calculated value as this has been found experimentally to give good compensation.

In a subsequent letter† Mr. D. C. Gall described a graphical method similar in principle to that described above and showed by plotting values measured off the graph that, over a wide range of values of $\omega L/R_2$, the correct value of C was 0.44 and not 0.41 times L/R_2^2. (Mr. Carter pointed out that this difference was due to graphical inaccuracy on Mr. Gall's part). He also assumed R_1 to have a negligible effect.

Mr. Albert Campbell wrote‡ pointing out that the resistance R_1 of the coil is not always negligible and that a more accurate formula for finding the capacitance is

$$C = \frac{\sqrt{2}\sqrt{1 + R_1/R_2} - 1}{1 + 2R_1/R_2} \cdot \frac{L}{R_2^2} \cdot 10^6\ \mu F$$

which reduces to $(\sqrt{2} - 1)\dfrac{L}{R_2^2} \cdot 10^6\ \mu F$ if R_1/R_2 is negligibly small.

Applied to the two examples Mr. Campbell's formula gives $0.403\dfrac{L}{R_2^2} = 0.0432\ \mu F$ and $0.400\dfrac{L}{R_2^2}$ $0.0445\ \mu F$.

Mr. Campbell subsequently pointed out that if R_1/R_2 is a small fraction so that $\sqrt{1 + R_1/R_2}$ can be put equal to $1 + R_1/2R_2$ and $1/(1 + 2R_1/R_2)$ to $(1 - 2R_1/R_2)$, the above formula reduces to

$$C = 0.41\left(1 - 0.3\frac{R_1}{R_2}\right)\frac{L}{R_2^2}\, 10^6\ \mu F.$$

Applied to the two examples this gives $0.400\dfrac{L}{R_2^2}$ and $0.395\dfrac{L}{R_2^2}$ i.e. 0.0428 and $0.0438\ \mu F$ respectively, the accurate values being 0.0418 and $0.044\ \mu F$.

Mr. Campbell's formulae are thus very accurate and certainly much simpler to use than the trigonometrical method developed above.

The problem is treated correctly in Dover's "Theory and Practice of Alternating Currents," p. 357, and an example is worked out using a formula which may be written thus:—

$$C = \frac{\sqrt{2}\sqrt{1 - X^2/2R_2^2} - 1}{1 - X^2/R_2^2} \cdot \frac{L}{R_2^2} \cdot 10^6\ \mu F$$

R_1 does not appear in it; it is assumed to be small compared with R_2 and if this is so, the formula gives a very close approximation.

G. W. O. H.

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* *Journ. of Scient. Inst.*, IX, p. 322, Oct. 1932.

† *Loc. cit*, IX, p. 361, Nov. 1932.

‡ *Loc cit.* X, p. 24, Jan., and p. 121, April 1933.

Noise Suppression by Means of Amplitude Limiters*

By Martin Wald, D.Ing.

AMPLITUDE limiter circuits are well known and often used in modern communication receivers to reduce the effect of atmospherics and other interference, the peak amplitude of which may be many times greater than the signal amplitude. It is generally considered that amplitude limiter circuits of any kind cannot be effective when the noise oscillations are smaller than the signal amplitude. We will, however, show in this article that, if certain conditions are fulfilled, amplitude limiter circuits may also improve the noise-to-signal ratio for noise oscillations under the signal amplitude. Such a noise suppression circuit, developed by the writer, is based on the following considerations. A noise impulse induced in the aerial of a receiver may be considered as the sum of a number of sine oscillations covering a very large frequency range. Usually when we speak of the noise to signal ratio, only the components falling within the passband of the receiver are included, since the other components cannot pass through the filter circuits to the audio-frequency part. Hence, this is in fact the ratio measurable behind the filter circuits of the receiver. If, however, we measure the noise-to-signal ratio before the filter circuits, we will find it considerably increased, since at this point the noise components of all frequencies are present, producing a higher amplitude of the noise voltage. On the other hand, the amplitude of the signal voltage will be the same across both the input and output terminals of the filter circuits, since all the signal frequencies lie within the passband of the latter. From these considerations it is clear that the ratio of noise peak voltage to signal amplitude obtained by aperiodic measuring instruments will give different figures if measured at different terminals of the receiver, depending on the frequency band-width allowed to pass all the circuits preceding the terminals in question. At points of poor selectivity, for instance, across the input circuit connected to the aerial, the measured noise-to-signal ratio will be much greater than at points of high selectivity, for instance across the circuit connected to the second detector. If, however, we use a measuring instrument equipped with filtering circuits of a band-width equal to that of the receiver in question, the same ratio will be obtained at any point of the receiver from the aerial up to the second detector, assuming linear operating conditions. For the sake of distinction, we will introduce the expressions selective noise-to-signal ratio and aperiodic noise-to-signal ratio. They are equal if measured across the last circuit of the receiver, where the full selectivity is available. If measured at points of large band-width, however, the aperiodic noise-to-signal ratio is greater than the selective noise-to-signal ratio. Now, at this point of the receiver we imagine an amplitude limiter interposed. The noise voltage exceeding the response limit will be reduced by the limiter, whereby also the components within the passband of the receiver will be attenuated in some measure in spite of the fact that the latter components alone would give an amplitude smaller than the response limit. We suppose the response limit to be twice the signal amplitude. In this case the limiter action begins as soon as the aperiodic noise-to-signal ratio becomes equal to 1. However, at the same time, the selective noise-to-signal ratio will be less than 1. The improvement realised in this way becomes evidently greater with increasing discrepancy between aperiodic and selective noise-to-signal ratio available across the limiter. For this purpose we have to make the band-width of all circuits before the limiter as large as possible, whilst behind the limiter we use circuits of high selectivity, the passbands of which are not larger than is necessary for good quality. We obtain thus the schematic circuit arrangement shown in Fig. 1. The aerial feeds into

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* MS. accepted by the Editor, May, 1940.

the filter F_1, the band-width w_1 of which is many times greater than w_2 that of the receiving filter F_2. The amplitude limiter L is interposed between the filters F_1 and F_2

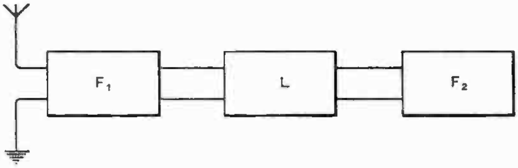

Fig. 1.

As will be shown later, the improvement obtained is given approximately by the ratio $\frac{w_2}{w_1}$. The selective noise-to-signal ratio at which the limiter action begins is $\frac{w_2}{w_1}$ if the response limit is adjusted to twice the signal amplitude. In ordinary limiter circuits $\frac{w_2}{w_1} = 1$.

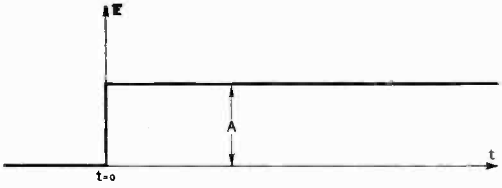

Fig. 2.

To obtain an idea of the noise reduction to be expected, we will investigate the working of such a circuit arrangement under simplified conditions. We assume the simple waveform shown in Fig. 2 to act on the aerial. The impressed voltage E jumps suddenly from the value $E = 0$ to $E = A$ at the instant $t = 0$, remaining afterwards constant at this level. We will hereinafter call a voltage of this form an ideal shock voltage. Furthermore, we suppose the filters F_1 and F_2 to be simple oscillating circuits, as shown in Fig. 3. The aerial is coupled aperiodically by means of the ohmic resistance R_A to the grid of the amplifier V_1 the anode of which is connected to the oscillating circuit F_1. The latter is deliberately damped by the variable resistance R_1 connected in series with the tuning coil L. By adjusting R_1 any desired band-width of the circuit F_1 can be established. Between F_1 and valve V_2 we interpose an amplitude limiter in the well-known form of two diodes D_1 and D_2 the bias due to the battery B determining the response limit. The amplifier V_2 feeds into the oscillating circuit F_2 which may be the input circuit of the receiver R. The band-width of F_2 is selected as small as possible but wide enough to pass the wanted signal frequencies. The band-width of F_1 will be adjusted by means of R_1 to be many times that of F_2. We now suppose an ideal shock voltage to occur in the aerial and calculate the time curve of the noise oscillations in the circuits F_1 and F_2. For the oscillation in F_1 we obtain the relations :

$$i_{a1} = g_1 A = i_c - i_L \quad .. \quad .. \quad (1)$$

and

$$L\frac{di_L}{dt} + R_1 i_L + \int \frac{i_c dt}{C} = 0 \quad .. \quad (2)$$

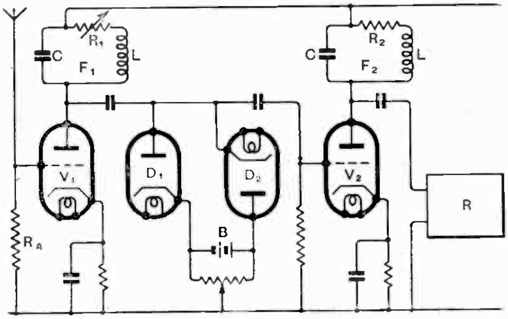

Fig. 3.

where i_{a1} is the anode current of the valve V_1, g_1 the mutual conductance of V_1, A the amplitude of the impressed shock voltage, i_c the current in the tuning condenser, i_L the current in the tuning coil of the circuit F_1, R, L, C the resistance, inductance, and capacitance in F_1 respectively. As can be easily shown, the solution of equations (1) and (2) gives damped sine oscillations represented by :

$$E_1 = g_1 A \sqrt{\frac{L}{C}} \, . \, e^{-\delta_1 t} \, . \sin 2\pi f_1 t \quad .. \quad (3)$$

where E_1 is the voltage across the circuit F_1, $\delta_1 = \frac{R_1}{2L}$ the damping factor and $f_1 = \frac{1}{2\pi} \cdot \frac{1}{\sqrt{LC}}$ the tuning frequency of the circuit. At first, we suppose E_1 to be below the response limit of the limiter $D_1 D_2$ and, therefore, the oscillations expressed in equation (3) to be acting on the grid of the valve V_2. For the oscillations in F_2 we have the analogous equations:

$$i_{a2} = g_2 E_1 = i_{c2} - i_{L2} \quad .. \quad (4)$$

$$\text{and } L\frac{di_{L2}}{dt} + R_2 i_{L2} + \int\frac{i_{c2}dt}{C} = 0 \quad .. \quad (5)$$

where g_2 is the mutual conductance of V_2, i_{a2} the anode current, i_{c2} and i_{L2} the currents in the tuning condenser and coil respectively, L and C the circuit inductance and capacitance of F_2, both supposed to be equal to the corresponding components in F_1 whilst the series resistance R_2 is small compared with R_1. Eliminating i_{c2} we get:

$$L\frac{di_{L2}}{dt} + R_2 i_{L2} + \int\frac{i_{L2}dt}{C} = -\int\frac{g_2 E_2 dt}{C} \quad .. \quad (6)$$

which represents the differential equation of an oscillating circuit, in which the expression on the right-hand side represents an external voltage acting on the circuit. Fig. 4 shows the equivalent diagram. The generator G with zero internal resistance supplies the electromotive force $-\int\frac{g_2E_2dt}{C}$, the time curve of which is given by equation (3) as a damped sine oscillation. As is known, the voltage arising across the circuit in Fig. 4 can be represented as the sum of two damped sine oscillations, the first one having the damping factor δ_1 and frequency f_1 of the impressed voltage, and the second one the natural damping factor and frequency of the circuit. We suppose both circuits F_1 and F_2 to have the same frequency f but different damping factors $\delta_1 = \frac{R_1}{2L}$ and $\delta_2 = \frac{R_2}{2L}$.

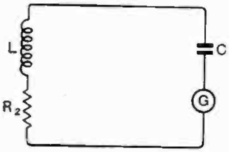

Fig. 4.

Hence, for the voltage arising across the circuit F_2 we may write:

$$\int\frac{i_{L2}dt}{C} = E_2 = E_{2i} + E_{2f}$$

$$= \mu_1 e^{-\delta_1 t}\cdot\sin(2\pi ft + \phi_1)$$

$$+ \mu_2 e^{-\delta_2 t}\cdot\sin(2\pi ft + \phi_2) \quad .. \quad (7)$$

where E_{2i} is the oscillation with the damping δ_1 corresponding to the impressed voltage, and E_{2f} the free oscillation with the circuit damping factor $\delta_2 = \frac{R_2}{2L}$. As at the time $t = 0$ no oscillations are present, they must have the same amplitude and opposite phase, thus cancelling each other at the instant $t = 0$, so that:

$$\left.\begin{aligned} &\mu_1 = \mu_2 = \mu \\ \text{and} \quad &\phi = \phi_1 = \phi_2 + \pi \end{aligned}\right\} \quad .. \quad (8)$$

From (7) we obtain:

$$\int\frac{i_{L2}dt}{C} = E_2 = E_{2i} + E_{2f}$$

$$= \mu\left[e^{-\delta_1 t} - e^{-\delta_2 t}\right]\sin(2\pi ft + \phi) \quad .. \quad (9)$$

On substituting the expressions (9) and (3) in the differential equation (6) we obtain two equations from which the amplitude μ and phase angle ϕ can be calculated. The calculation will be considerably simplified if we suppose δ_2 to be small compared with δ_1 and the two of them to be small compared with $\omega = 2\pi f = \frac{1}{\sqrt{LC}}$. With these assumptions and neglecting small second order terms, we obtain from (6):

$$LC\mu[-\omega^2\sin(\omega t + \phi) - 2\delta_1\omega\cos(\omega t + \phi)]$$

$$+ \mu\sin(\omega t + \phi) =$$

$$= -\frac{g_2}{C}g_1 A\sqrt{\frac{L}{C}}\left(-\frac{1}{\omega}\cdot\cos\omega t\right)$$

On putting $\omega^2 = \frac{1}{LC}$; $\delta_1 = \frac{R_1}{2L}$ and $\delta_2 = \frac{R_2}{2L}$ the latter equation is reduced to:

$$-\mu\frac{R_1}{L}\sqrt{LC}\cdot\cos(\omega t + \phi) = g_2 g_1 A\frac{L}{C}\cos\omega t \quad .. \quad .. \quad (10)$$

On equating amplitudes and phase angles in (10) we have

$$\left.\begin{aligned} &\phi = 0 \\ \text{and} \quad &\mu = -g_1 g_2 A\sqrt{\frac{L}{C}}\cdot\frac{L}{CR_1} \end{aligned}\right\} \quad .. \quad (11)$$

Finally, from (11) and (9):

$$E_2 = g_1 A\sqrt{\frac{L}{C}}\cdot g_2\frac{L}{CR_1}\left(e^{-\delta_1 t} - e^{-\delta_2 t}\right)\sin 2\pi ft \quad .. \quad .. \quad (12)$$

Fig. 5 shows the time curve of the noise oscillations caused by an ideal shock voltage acting on the arrangement according to Fig. 3. The upper curve *a* shows an ideal shock voltage of amplitude A acting on the aerial. Curve *b* shows the oscillations set up in the circuit F_1 according to equation (3), and curve *c* the oscillations in F_2 according to equation (12). The oscillations in F_1 rapidly decrease on account of the large damping factor $\delta_1 = \frac{R_1}{2L}$. At the same time, however, the oscillations in F_2 increase until they reach a maximum, after which they slowly decrease due to the small damping factor $\delta_2 = \frac{R_2}{2L}$ of the circuit F_2. Further, we suppose that a signal of the amplitude B is continuously acting on the aerial. The aperiodic noise-to-signal ratio across the circuits F_1 and F_2 can be easily calculated from the above deduced relations. We obtain the following noise-peak-voltages, denoted by N_A, N_1, and N_2 respectively :

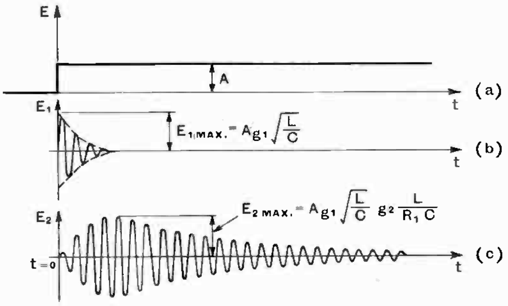

Fig. 5.

$$\left.\begin{array}{l}
\text{Across the aerial :} \\
\qquad N_A = A \\
\text{Across } F_1 \text{ from equation (3)} \\
\quad \text{and Fig. } 5b : \\
\qquad N_1 = Ag_1\sqrt{\dfrac{L}{C}} \\
\text{Across } F_2 \text{ from equation (12)} \\
\quad \text{and Fig. } 5c : \\
\qquad N_2 = Ag_1\sqrt{\dfrac{L}{C}} \cdot g_2 \dfrac{L}{R_1C}
\end{array}\right\} \quad \ldots \; (13)$$

For the signal voltage amplitudes, denoted by S_A, S_1, S_2 respectively, we obtain :

$$\left.\begin{array}{l}
\text{Across the aerial :} \\
\qquad S_A = B \\
\text{Across the circuit } F_1 : \\
\qquad S_1 = Bg_1 \dfrac{L}{R_1C} \\
\text{Across the circuit } F_2 : \\
\qquad S_2 = Bg_1 \dfrac{L}{R_1C} \cdot g_2 \dfrac{L}{R_2C}
\end{array}\right\} \quad \ldots \; (14)$$

where $\frac{L}{R_1C}$ and $\frac{L}{R_2C}$ represent the resonant impedance of the circuits F_1 and F_2 respectively.

For the aperiodic noise-to-signal ratio we obtain from equations (13) and (14) :

$$\left.\begin{array}{l}
\text{Across the aerial: } \left(\dfrac{N}{S}\right)_A = \dfrac{A}{B} \\
\text{Across the circuit } F_1 : \\
\qquad \left(\dfrac{N}{S}\right)_{F_1} = \dfrac{A}{B} \cdot \dfrac{R_1}{\sqrt{\dfrac{L}{C}}} \\
\text{Across the circuit } F_2 : \\
\qquad \left(\dfrac{N}{S}\right)_{F_2} = \dfrac{A}{B} \cdot \dfrac{R_2}{\sqrt{\dfrac{L}{C}}}
\end{array}\right\} \quad \ldots \; (15)$$

The aperiodic noise-to-signal ratio at F_2 is therefore considerably smaller than that at F_1 since R_2 is supposed to be much smaller than R_1. From (15) we get :

$$\frac{\left(\dfrac{N}{S}\right)_{F_2}}{\left(\dfrac{N}{S}\right)_{F_1}} = \frac{R_2}{R_1} \qquad \ldots \quad \ldots \; (16)$$

In equation (16) we will introduce the circuit band-widths w_1 and w_2 instead of the loss resistances R_1 and R_2. The band-width of a circuit is defined as the frequency interval, corresponding to a drop of the resonant curve to $\frac{1}{\sqrt{2}}$ of its maximum value. This band-width is inversely proportional to the goodness of the circuit in question and can be written as :

$$w = \frac{R}{\sqrt{\dfrac{L}{C}}} f \qquad \ldots \quad \ldots \; (17)$$

where w is the band-width in c/s, R the series loss resistance of the circuit in ohms, L the circuit inductance in henrys, C the capacitance in farads, and f the tuning frequency of the circuit in c/s. This formula holds so long as w can be considered small compared with f. From (17) and (16) follows :

$$\frac{\left(\frac{N}{S}\right)_{F_2}}{\left(\frac{N}{S}\right)_{F_1}} = \frac{w_2}{w_1} \quad \ldots \quad \ldots \quad (18)$$

Equation (18) says that, at any point of a receiver, the aperiodic noise-to-signal ratio is directly proportional to the band-width available at the terminal point in question. However, the selective noise-to-signal ratio, which is all that matters for reception quality, will be the same, irrespective of the circuit across which it is measured. Across the circuit F_2, where the full selectivity of the receiver is available the aperiodic and selective noise-to-signal ratio are equal to each other. Hence, we have :

$$\left(\frac{N}{S}\right)_{\text{sel}} = \left(\frac{N}{S}\right)_{F_2} = \frac{w_2}{w_1}\left(\frac{N}{S}\right)_{F_1} \quad \ldots \quad (19)$$

where $\left(\frac{N}{S}\right)_{\text{sel}}$ denotes the selective noise-to-signal ratio as defined above. We suppose the response limit of the limiter D_1D_2 in Fig. 3 to be twice the signal amplitude available across it. In this case the limiter action begins as soon as the aperiodic noise-to-signal ratio $\left(\frac{N}{S}\right)_{F_1}$ reaches unity. Hence the operation threshold is given by :

$$\left(\frac{N}{S}\right)_{F_1} = 1 \quad \ldots \quad \ldots \quad (20)$$

At the same time for the selective noise-to-signal ratio it follows from (19) and (20) that

$$\left(\frac{N}{S}\right)_{\text{sel}} = \frac{w_2}{w_1} \quad \ldots \quad \ldots \quad (21)$$

which is according to the preceding assumptions, a figure much smaller than unity. Equation (21) says that, unlike ordinary limiter circuits, the limiter in question becomes effective at a selective noise-to-signal ratio $\frac{w_2}{w_1}$ much smaller than 1. The ratio $\frac{w_2}{w_1}$ can be called the improvement factor, since the limiter begins to act as soon as the noise voltage across F_2 exceeds the fraction $\frac{w_2}{w_1}$ of the signal voltage, whilst in ordinary limiter circuits, the limiter being arranged behind the filter F_2, noise oscillations less than the signal amplitude will not be influenced by the limiter. In order to obtain an efficient noise reduction, we require the selective noise-to-signal ratio at which the limiter action begins, to be smaller than 3 per cent. This gives with regard to (21) :

$$\frac{w_2}{w_1} \leqq 0.03 \quad \ldots \quad \ldots \quad (22)$$

which means that the band-width w of the circuit F before the limiter must be at least about 30 times that of the circuits following the limiter. On the other hand, it is clear that for good working, the amplitude limiter ought not to be affected by any other stations than the one wanted, otherwise cross modulation will occur ; the response limit must be adjusted to be greater than the amplitude of the strongest of them. However, in this case if receiving a weak signal—the circuit F_2 behind the limiter being tuned to the weak signal—no noise reducing effect will be noticed since the response limit will be adjusted to a value many times greater than that of the wanted signal. This requirement restricts the field of application of the noise suppression circuit described above to cases in which the frequency separation between neighbouring stations is many times (about 30 times) greater than the band-width of the modulated signal to be received. On the medium, long, and short wave ranges the broadcasting frequencies are close together and therefore the latter requirement cannot be satisfied. In the ultra-short wave range, however, the condition is well fulfilled and therefore ultra-short wave reception is the field in which the noise suppression circuit, described above, can be applied. As an important application the writer suggests the incorporation of such a noise suppression circuit in the sound part of a television receiver in order to reduce efficiently atmospherics and motor car interference. For the band-width w_2 we choose 15 kc/s which is a usual figure for quality receivers. From equation (22) we obtain the band-width of the circuits ahead of the limiter :

$$w_1 = \frac{w_2}{0.03} = \frac{15}{0.03} \doteq 500 \text{ kc/s} \quad .. \quad (23)$$

which value can be easily realised in ultra-short reception without interfering troubles due to neighbouring stations.

Fig. 6 shows an example of a circuit diagram for an ultra-short wave sound receiver incorporating the noise suppression circuit described above. The aerial feeds into the R.F. stage V_1 with circuits (C_1 and C_2) tuned to the signal frequency of about 42 Mc/s (7 m wavelength) which is followed by the first mixer V_2. Further follow two I.F. stages, V_3 and V_4. Here the I.F. is chosen at 5 Mc/s, to which the circuits C_3, C_4 and C_5 are tuned. The band-width of the latter three circuits is adjusted to 500 kc/s. The amplification per stage depends on the resonant impedance of these circuits. This is given by

$$Z = \frac{1}{2\pi C w} \quad .. \quad .. \quad (24)$$

where Z denotes the impedance in ohms, C the circuit capacitance (including valve capacitances) in farads, w the band-width in c/s. For the capacitance C we choose the somewhat large value of 50 $\mu\mu$F in order to prevent serious detuning by variation of the valve capacitances by the A.V.C. voltages incorporated in these stages. An efficient A.V.C. is provided for obtaining an approximately constant signal amplitude across the following limiter stage. With $w = 500$ kc/s and $C = 50 \mu\mu$F formula (24) gives : $Z = 6{,}500$ ohms and the amplification per stage will be about 20 times, assuming a pentode with a mutual conductance of about 3 mA/volt. The gain in the R.F. stage V_1 we put at six times and the same for the mixer stage V_2. The total maximum gain from the grid of V_1 up to the limiter L may be :

$$6 \times 6 \times 20 \times 20 = 15{,}000.$$

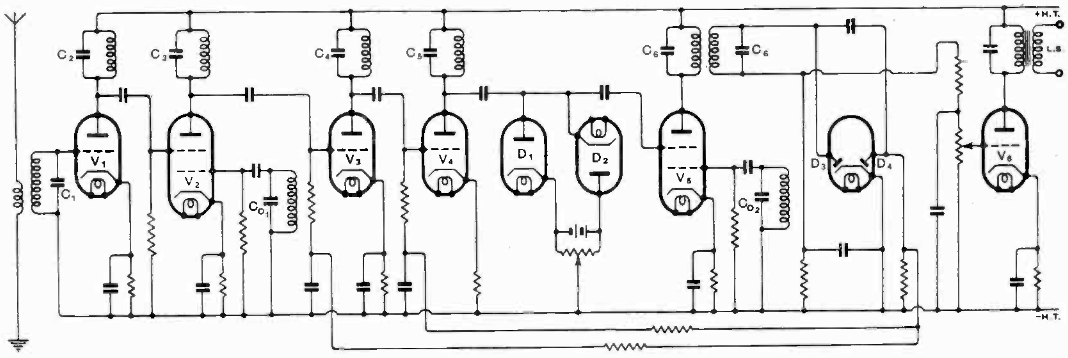

Fig. 6.

The response limit of the limiter L we suppose to be about 2 volts. Hence for input voltages acting on the grid of V_1 amounting to about 70 μV, the limiter will enter in action. The limiter is represented as a combination of two diodes but it may take other forms. Behind the limiter we have a second mixer stage V_5 in order to reduce the I.F. from 5 Mc/s to 450 kc/s, to which the I.F. filter C_6 is tuned. The band-width w_2 of the latter should be as small as possible in order to obtain a favourable improvement factor $\frac{w_2}{w_1}$. We have chosen $w_2 = 15$ kc/s, a figure sufficient for tone quality, and obtain :

$$\frac{w_2}{w_1} = \frac{15}{500} \doteq 0.03 \quad .. \quad .. \quad (25)$$

$\frac{w_2}{w_1} = 0.03$ represents the selective noise-to-signal ratio available across C_6 and detector diode D_3 for the case in which the aperiodic noise-to-signal ratio across C_5, ahead of the limiter, is unity. With increasing noise voltages the part of the voltage curve exceeding the response limit will be cut off by the limiter as shown in Fig. 7. The curve 7*b* results from a noise voltage ten times greater than the response limit. The dotted line shows the part cut off by the limiter. Compared with 7*a*, where the noise voltage does not exceed the response limit, we see that though the peak voltages passing the limiter are the same, the time duration of the noise oscillations are different in the two cases. Obviously we can write :

$$T_2 = T_1 + \frac{1}{\delta_1} ln \frac{\alpha_2}{\alpha_1}^{*} \quad \text{or}$$

$$\frac{T_2}{T_1} = \frac{1}{\delta_1 T_1} ln \frac{\alpha_2}{\alpha_1} + 1 \quad \ldots \quad (26)$$

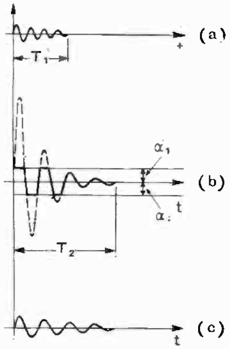

Fig. 7.

where T_1 and T_2 respectively denote the time necessary for the oscillations to fall to the negligible value $\alpha_1 l^{-\delta_1 T_1}$, for instance, to a seventh of the response limit, α_2 the amplitude before cut off by the limiter, and α_1 the response limit. The same effect, that is an extension of the duration of the noise oscillations would be obtained by decreasing the damping factor δ_1 of the circuit preceding the limiter. Therefore for calculating the noise oscillations arising across C_6 after the limiter, as an approximation, we replace curve 7*b* by the curve 7*c* which is a damped sine oscillation with an amplitude equal to the response limit and a damping factor $\frac{R'_1}{2L}$, being $\frac{T_2}{T_1}$ times smaller than the real damping factor $\delta_1 = \frac{R_1}{2L}$. We have for the equivalent loss resistance in the case where $\alpha_2 > \alpha_1$ and $\delta_1 T_1 = \frac{1}{2}$:

$$R'_1 = \frac{R_1}{1 + \frac{1}{2} ln \frac{\alpha_2}{\alpha_1}} \quad \ldots \quad \ldots \quad (27)$$

The amplitude of the noise oscillations arising across C_6 is according to equation (12), inversely proportional to the loss resistance R'_1 of the preceding circuits. For the selective noise-to-signal ratio we obtain from (27) and (21), and replacing α_1 by the doubled signal amplitude $2S$:

$$\left(\frac{N}{2S}\right)_{\text{sel } C_6} = \frac{w_2}{w_1}\left[\frac{1}{2} ln \left(\frac{N}{2S}\right)_{C_4} + 1\right] \quad \ldots \quad (28)$$

Fig. 8 shows the curve representing equation (28). It is seen that the selective noise-to-signal ratio across C_6 is not rigorously limited to the value $\frac{w_2}{w_1}$ but increases very slowly with increasing aperiodic noise-to-signal ratio available ahead of the limiter. The filter C_6 feeds the signal rectifier diode D_3 and the A.V.C. diode D_4. The A.V.C. will be adjusted to give a constant signal amplitude across the limiter of about one-half the response limit. The signal rectifier D_3 is followed by the output valve V_5.

There is an interesting analogy between the noise suppressing system described in this article and the Armstrong system of frequency modulation, experiments on which have been made in America in the ultra-short wave range. The Armstrong receiver contains (see *Wireless World*, May 18th, 1939, page 469, "Frequency Modulation in America") an amplitude limiter stage, the R.F. and I.F. circuits before the limiter having a band-width of more than 200 kc/s (this is the channel width required for Armstrong modulation) and the audio-frequency part of the receiver having a passband of about 15 kc/s. Hence, it shows all the characteristics of the noise suppression circuit described in this article. The question arises whether the improvement in the noise-to-signal ratio in the Armstrong system may not be explained in this way and have nothing to do with the type of modulation. In a later article we hope to investigate the Armstrong receiver from this point of view.

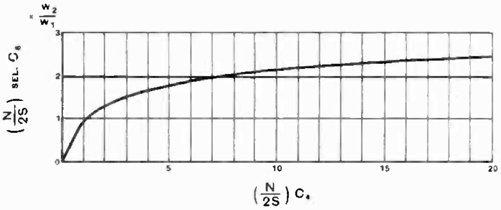

Fig. 8.

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* $ln\, x = \log_e x$.

Phase Adjuster*

Continuously Variable Device with Constant Amplitude

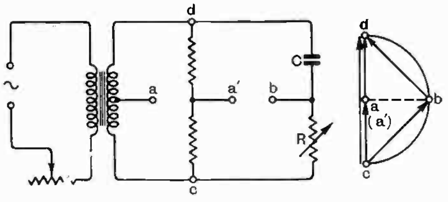
By K. Kreielsheimer, D.Ing., F.Inst.P.

(Research Physicist of the New Zealand Radio Research Committee)

SUMMARY.—The device described in the present article is designed to allow the continuous shifting of the phase angle between two A.C. voltages, by known amounts. This is done with two resistance-capacitance combinations.

In principle there are two methods of producing known phase angles, the one device using a rotating magnetic field which induces E.M.F. in stationary coils inserted in this field at chosen angles (K. Lion, *E.N.T.*, Vol. 15, pp. 276–283, 1928), and the other design using electric circuits with impedances so arranged as to produce phase-altered output voltages. O. O. Pulley (*Wireless Engineer*, Vol. XIII, pp. 593–594, 1936) describes a device which allows for a continuously variable phase shift; it has, however, the disadvantage that the output voltage varies from a maximum to a minimum and back to a maximum in a ratio of $\sqrt{2}$ during each phase change of 90°, and that it is difficult to calibrate. Whilst Pulley's arrangement employs resistances, condensers and inductances, the more commonly used type comprises a resistance-capacitance combination only, either in a single circuit connection or in a bridge circuit, the phase change being effected normally by varying the resistance.

Fig. 1a shows a general resistance-capacitance device as a bridge circuit with centre tapping of the transformer secondary at a, or with artificial centre point of the transformer output voltage at a'. R may be a variable resistance or a potential divider. In either case the vector diagram of Fig. 1b applies; if R is a potential divider, the voltage of point b varies along the vector c–b, while if R is a variable resistance, the point b will move along the arc c–b, i.e., the voltage a–b remains constant and equal to $\frac{1}{2}$ $(d–c)$. The phase variation obtainable in either case will be considerably less than 180° and if R is used as a variable resistance the impedance of this circuit is not constant. By extending the circuit of Fig. 1a, however, and using this device to cover a phase difference of 90° only, whilst the 4 quadrants are covered by a separate switching arrangement the complete phase differences from 0° to 360° can easily be effected without any " blind " spots.



(a) (b)

Fig. 1.

Fig. 2a shows the proposed circuit, which allows for a continuous calibrated phase shift, keeping at the same time the output amplitude constant and equal to the input voltage. As is apparent from the diagram, the whole circuit consists of resistances and condensers only. The condensers C and the resistances R are provided in order to balance the arrangement relative to the earth point. The resistances R_1 and R_2 and the condensers C_1 and C_2 are equal and so dimensioned as to ensure $R_1 = R_2 = \frac{1}{\omega C_1} = \frac{1}{\omega C_2}$ (ω = angular input frequency). The phase angle between the voltage and the current in the branch $a\ c\ b$ and $a\ d\ b$ is then the same and amounts to 45°. Fig. 2b shows the conditions in a vector diagram. The voltage c–d is equal to a–b with a phase difference of 90°. The same diagram applies for the circuit which contains R_3, C_3, R_4, C_4. This internal circuit, however, contains variable components, either variable resistances R_3 and R_4 (instead of which potential dividers could be used) or variable condensers C_3 and C_4. Let us assume R_3 and R_4 to be variable resistors which change equally in value

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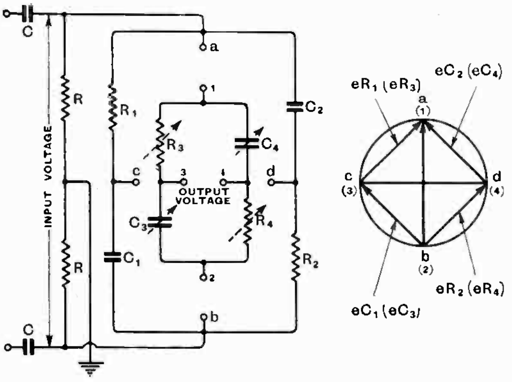
* MS. accepted by the Editor, July, 1940.

simultaneously. Commencing with zero resistance in branches 1–3–2 and 1–4–2, the current would be 90° leading in phase in regard to voltage 1–2. With increasing resistance R_3 and R_4 the phase angle decreases, and for $R_3 = R_4 = \frac{1}{\omega C_3} = \frac{1}{\omega C_4}$ we again obtain a phase angle of 45° or analogous to Fig. 2b, 90° between voltage 1–2 and 3–4. The values should be chosen to make the impedance between the points 1 and 2 large compared with the input impedance between *a* and *b*. Similarly, the output impedance between 3 and 4 has to be large compared with impedance between 1 and 2, since otherwise the theoretical phase relations between the various voltages and the voltages themselves as represented by the vector diagram in Fig. 2b would be affected. This has to be kept in mind if it is desired to make the output voltage variable by placing a potential divider across the output terminals 3–4. As circumstances permit it will often be more advisable to achieve this output variation by controlling the amplitude of the input voltage.



(a) (b)

Fig. 2.

A special switch which allows point 1 to be connected alternately to points *a*, *c*, *b*, *d* and at the same time point 2 to points *b*, *d*, *a*, *c*, completes the arrangement. Whilst the variation of the resistances R_3 and R_4 enables us to change the phase 90°, the switch serves to select the quadrant. In practice it will be advisable to overlap the quadrants slightly by providing for a somewhat greater phase variation than 90°. Using variable resistances or variable condensers the voltage vector travels along the circumference of the circle of Fig. 2b, i.e., the output voltage is of the same amplitude as the input voltage. The impedance of the whole arrangement, however, changes with the phase adjustment. If it should be desired to keep the impedance of the apparatus constant, potential dividers have to be used in place of the variable resistances. This effects a change in output voltage, the ratio of the maximum to the minimum being $\sqrt{2}$, provided that the value of the potential dividers R_3 and R_4 is equal to $\frac{1}{C\omega_3}$ and $\frac{1}{\omega C_4}$, as now the ends of the voltage vector 3–4 slide along the chord 1–3 and 2–4, thus making overlapping of the various quadrants impossible. Care has to be taken in matching the impedances of the various circuits incorporated in the design of this apparatus since a deviation from the theoretical phase is unavoidable if the inner circuit 1–3–2–4 represents an appreciable load on the outer one *a–c–b–d*. In this latter case it would be advisable to obtain the calibration experimentally by producing ellipses of known phase difference on the screen of a cathode-ray oscillograph and compensating the phase angle to zero by inserting our device in the connection leading to one pair of deflection plates.

Obviously the accuracy and reproducibility of the calibration depend largely on the exactness with which the frequency used can be kept constant. In the present case the circuit has been designed for a tuning fork oscillator of 1024 cycles/sec. If the circuit is required for various discrete frequencies or bands of frequencies, means have to be provided to change the values of R_1 and R_2 or C_1 and C_2 respectively so as to make the resistances equal to the condenser impedances for the frequencies in question and separate calibrations will have to be provided for each frequency; depending on the frequency range, the values of R_3 and R_4 or C_3 and C_4 might be affected as well.

In the present design as shown by Fig. 3 the variable components are condensers, C_3 and C_4, the maximum capacitance of which is 1379 $\mu\mu$F, the minimum capacitance 43 $\mu\mu$F each, as determined by exact bridge measurement. Both condensers are mounted on a common shaft but separated by an insulating coupling and fitted with a precision dial. The fixed resistances R_3 and R_4 are of the carbon type, carefully adjusted to be equal and are each 2.4 megohms. (Variable condensers and resistors of high value had to be selected as no suitable variable resistances of about 100,000 ohms–200,000 ohms were obtainable in the Dominion. This forced us to make the impedance of the inner circuit unnecessarily high.) R_1 and R_2 are represented by 13,515 ohm wirewound resistors which were combined with C_1 and C_2, each of 0.0115 μF, all parts being carefully adjusted in value. When testing the circuit *a–c–b–d* with the oscillograph, a perfect circle could be obtained only after balancing the inductivity of the two wirewound resistors. Condensers, 0.0008 μF parallel to R_1 and 0.001 μF parallel to R_2, serve this purpose. The apparatus was mounted entirely on bakelite. Because of the high impedances involved, care had to be exercised regarding the distribution of earth capacitances and the distribution of inductance and capacitance between the circuits.

Summarising; the phase adjustment device described above is characterised by the following features: viz.—with the aid of two controls, one for phase and the other for quadrant adjustment, it is possible to obtain a continuously variable calibrated phase shift over 360°, whereby the output voltage remains constant and equal to the input voltage. The four quadrants can be made to overlap thus providing check measurements in this range for two neighbouring quadrants. The design employs conventional types of resistors and condensers which allow an easy and reliable construction. The quadrant switch is best described as of the double pole four throw type. Without influencing the phase adjustment the impedance of the arrangement can be made approximately constant for the entire working range.*

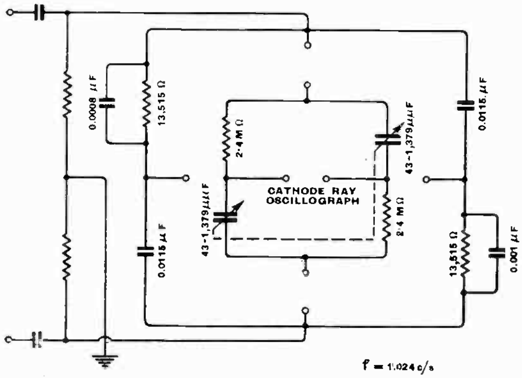


Fig. 3.

This work has been carried out at the Department of Physics of the Auckland University College in the course of investigations under the New Zealand Radio Research Committee. The author wishes to tender his acknowledgments to Professor P. W. Burbidge for his continued interest and encouragement and to the N.Z. Department of Scientific and Industrial Research for its kind permission to publish this article.

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* During the preparation of this article the Radio Research Board of Australia courteously submitted details of a new design of a phase shifter of somewhat similar properties based on Pulley's principle (*loc. cit.*) evolved by A. H. Mutton, and it is understood that Mutton's phase adjuster is in course of publication.

Correspondence

Feedback

To the Editor, The Wireless Engineer.

Sir,—Mr. Sandeman, in his article entitled "Feedback" (*The Wireless Engineer*, August, 1940, page 342) calls attention to the shift in modulation phase produced by a tuned circuit sufficiently sharp to attenuate appreciably the sidebands. This phenomenon is exceedingly troublesome in transmitters using low-power modulation (with, consequently, a number of tuned circuits in cascade) or using filter networks to reduce carrier harmonics, and the permissible amount of feedback is severely limited thereby. In some cases, it is required by specification that the higher harmonics of high modulation frequencies be reduced, and the problem of increasing the π-frequency becomes urgent.

The writer has found the filter section calculated by Zobel (*Bell S. Tech. Journ.*, July 1928, page 470, Fig. 8, right-hand section) of use in these circumstances. It has the property of negative lag over a range of frequencies, which is not wholly vitiated by its reduced attenuation at high frequencies. In a typical case, such a filter section introduced in the β chain has postponed the π-frequency by a factor 1,3 times.

London, S.W.12. C. E. G. Bailey.

Amplitude, Frequency and Phase Modulation

To the Editor, The Wireless Engineer.

Sir,—Reference your Editorial in the May 1940 issue, in the final paragraph you refer to a claim by Dr. Hughes that it is possible to have an amplitude modulated programme and a frequency modulated programme on the same transmitter simultaneously, but you seem to doubt the possibility of separate reception of the two programmes without cross talk. It is noted that Dr. Hughes stated that "this does not appear to have been practised." May I say that I have tried this method, using a 100-W. frequency modulated transmitter of the reactance valve type, being frequency modulated with one programme, and have modulated the final amplifier with cathode modulation with a second programme. The carrier frequency was 47 Mc/s. Using a simple super-regenerative receiver either programme can be received at will by tuning, with only a very slight amount of cross talk, and it certainly seems that given properly designed receivers for the reception of the two methods of modulation that undoubtedly the two programmes or channels could be received without interference. It should also be pointed out that when using the reactance type of F.M. transmitter and amplitude modulating the final amplifier, it is only reasonable to suppose that there is a certain amount of F.M. in the amplitude channel arising from the fact that the centre point of the carrier is not firmly anchored, but I suggest that if a transmitter of the type designed by Major Armstrong were used, with the advantage of a crystal controlled centre point, then the cross talk would be considerably reduced.

I may also state that I have also tried simultaneous F.M. and A.M. of the same transmitter with one programme only and find that the quality of the transmission appears to be better than with amplitude modulation only, and it is suggested that F.M. stations could employ this double modulation method during the transition period from one system to the other to enable their listeners who possess only A.M. receivers to enjoy the benefits of the U.H.F. quality, etc., whilst the listeners with F.M. receivers would get the additional benefits of noise reduction, etc. It is of course realised that a reduction of output would have to be made to allow for the peak swings of the amplitude modulation so the gain of employing the two methods of modulation on the one transmitter would not be 100%, but for point to point communication it opens up a second channel possibility with very small increased transmitter expenditure.

I certainly hope that Dr. Hughes will make suggestions for suitable receivers for this type of work. W. C. Gee.

P. and T. Dept.,
Kuala Lumpur,
Federated Malay States.

P.S.—Since writing the above letter further experiments have been made, to ascertain if stereophonic broadcasting could be carried out by using the two channels thus provided on the one transmitter, and, whilst receiving arrangements were necessarily crude it was quite obvious that this method could be used for this purpose. One of the greatest difficulties would appear to be that of prevention of mutual interaction of the two receivers necessary for reception but this could undoubtedly be overcome by the design of special double receivers for this work.

Wireless Patents

A Summary of Recently Accepted Specifications

The following abstracts are prepared, with the permission of the Controller of H.M. Stationery Office, from Specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each

RECEIVING CIRCUITS AND APPARATUS

(*See also under Television*)

521 882.—Receiver in which means for limiting the amplitude of the incoming signals are combined with means for balancing-out undesired signals.

Marconi's W.T. Co. (assignees of L. E. Thompson). Convention date (U.S.A.) 30th November, 1937.

521 983.—Visual tuning indicator with means for showing a gradual approach to the correct tuning point, even for strong signals.

M-O Valve Co. and C. W. Cosgrove. Application date 30th November, 1938.

522 248.—Spring-controlled arrangement for evening-out the pressure used to actuate the press-buttons of a mechanical tuning system.

E. K. Cole and A. Shackell. Application date 11th October, 1938.

522 258.—Controlling the fidelity and selectivity of a wireless receiver by passing the signals through two or more branch channels of different bandwidths.

Murphy Radio and L. A. Moxon. Application date 3rd December, 1938.

522 388.—Amplifier of the super-regenerative type specially adapted to receive radio telegraphic signals produced by keying an unmodulated carrier-wave.

The General Electric Co.; L. C. Stenning; and R. W. White. Application date 7th December, 1938.

522 476.—Variable-capacity effect, produced in the Johnson-Rahbeck manner, for applying automatic frequency control to a wireless receiver.

Marconi's W.T. Co.; N. M. Rust; J. D. Brailsford; and J. F. Ramsay. Application date 12th November, 1938.

522 525.—Preselector tuning arrangement of the endless-band type, for a wireless set.

Telefunken Co. Convention date (Germany) 11th December, 1937.

522 710.—Valve of the so-called "beam" type and with a split anode, particularly for use as a "mixer" or frequency-changer in a superhet set.

Marconi's W.T. Co. and D. A. Bell. Application date 13th December, 1938.

522 902.—Bridge circuit for eliminating hum or

ripple from the A.C. supply for heating the valve filaments of a wireless set.

Standard Telephones and Cables (communicated by Nippon Electric Co.). Application date 20th December, 1938.

522 939.—Discriminator circuit showing a response curve with three zero points for automatic frequency control.

Marconi's W.T. Co. and N. M. Rust. Application date 20th September, 1938.

TELEVISION CIRCUITS AND APPARATUS

For Transmission and Reception

522 317.—Arrangement and construction of the electrodes forming the "gun" of a cathode-ray television receiver.

O. Klemperer. Application date 10th December, 1938.

522 377.—Focusing arrangement for a tube of the "beam" or cathode-ray type in which rotation of the beam, due to the applied magnetic field, is prevented.

Ferranti ; M. K. Taylor ; and H. Wood. Application date 7th December, 1938.

522 387.—Thermionic amplifier circuit designed to give one output of constant and another output of variable gain, particularly for modulating the electron stream of a cathode-ray television receiver.

The General Electric Co. ; D. C. Espley ; and G. W. Edwards. Application date 7th December, 1938.

522 443.—Saw-toothed oscillation generator for supplying scanning voltages to the magnetic deflecting coils of a cathode-ray television receiver.

The General Electric Co. ; E. C. Cherry ; and R. J. Clayton. Application date 8th December, 1938.

522 458.—Television transmitter tube in which means are provided for controlling the secondary emission produced when scanning a photo-electric screen of the mosaic type.

H. G. Lubszynski. Application date 10th December, 1938.

522 495.—Oscillation-generator circuit, particularly for producing synchronising impulses for a television transmitter worked from the electric supply mains.

Marconi's W.T. Co. ; D. L. Plaistowe ; and C. E. Parkinson. Application date 13th December, 1938.

522 533.—Cathode-ray tube, particularly for television reception, in which the overall length of the tube is reduced by bending-over the "gun" end at right-angles to the main stem.

Kolster-Brandes and C. N. Smyth. Application date 13th December, 1938.

522 545.—Rotating-disc device for televising a film by interlaced scanning, provided with adjustable means for ensuring correct inter-lining.

The General Electric Co. and D. C. Espley. Application dates 15th December, 1938, *and 7th November,* 1939.

522 637.—Saw-tooth oscillation-generator particularly designed to produce a straight-line voltage on the forward or long flank of the wave-form.

E. W. Bull. Application date 16th December, 1938.

522 709.—Amplitude-limiting circuit for separating the synchronising impulses from the picture-signals in a television receiver.

Marconi's W.T. Co. and D. J. Fewings. Application date 13th December, 1938.

522 737.—Two-grid gas-filled discharge tube for generating saw-toothed oscillations, suitable for television scanning.

Murphy Radio and K. S. Davies. Application date 14th December, 1938.

522 860.—Photo-sensitive electrode with a selenide or telluride base, for generating television or other signals, particularly by infra-red radiation.

A. Carpmael (communicated by the Telefunken Co.). Application date 11th January, 1939.

522 903.—Means for correcting the kind of "brightness distortion" which arises when televising from a moving film by interlaced scanning.

The General Electric Co. and D. C. Espley. Application date 20th December, 1938.

522 951.—Cathode-ray tube in which the electrons emitted from a photo-sensitive surface are made to travel in a closed circle back to that surface in order to intensify television signals.

H. G. Lubszynski. Application date 20th December, 1938.

523 050.—Testing circuit for comparing the light intensity and gradation in a television transmitter.

Radio-Akt. D. S. Loewe. Convention date (Germany) 24th November, 1937.

523 075.—Remote-control device for regulating the "brightness" or gain of a television receiver.

Kolster-Brandes and P. M. Brand. Application date 23rd December, 1938.

TRANSMITTING CIRCUITS AND APPARATUS

(See also under Television)

522 428.—Circuit for producing a controlled low-frequency wave by "mixing" high and intermediate frequency oscillations, particularly for use in "wired" wireless systems.

Wired Radio Inc. Convention date (U.S.A.) 14th January, 1938.

522 429.—Detector circuit for receiving wired-wireless signals from which the carrier-wave has been removed at the transmitter.

Wired Radio Inc. Convention date (U.S.A.) 14th January, 1938.

522 477.—Electron-discharge tube in which a beam of electrons serves as a variable condenser, to compensate say for frequency-drift in a wireless transmitter.

Marconi's W.T. Co. ; G. F. Brett ; and N. Levin. Application date 12th November, 1938.

522 799.—Gain-control arrangement for improving the signal-to-noise ratio in a telephony transmission system including a radio-signal link.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon). Convention date (France) 18th February, 1938.

522 882.—Magnetron oscillator-modulator circuit with negative back-coupling for the modulation frequencies.

The General Electric Co. and N. E. Willshaw. Application dates 17th March, 1939, *and 24th January,* 1940.

522 889.—Impedance network for coupling receivers to a line distributing relayed broadcast programmes.

P. P. Eckersley and R. E. H. Carpenter. Application date 18th October, 1938.

522 905.—Multiple-anode discharge tube, of the magnetron type, for generating waves of the order of 10 centimetres.

Telefunken Co. Convention date (Germany) 20th December, 1937.

522 976.—Ultra-short-wave transmitter in which modulation is effected along the transmission line connecting the oscillator to the aerial.

J. L. Pawsey and E. L. C. White. Application date 22nd December, 1938.

523 009.—Feed-line of the "dielectric guide" type for transmitting very high-frequency currents as displacement waves.

Siemens and Halske Akt. Convention date (Germany) 21st December, 1937.

523 067.—Receiving arrangement for the calling signals on a line-wire multi-channel carrier-wave telephony system.

Philips' Lamp Co. Convention date (Germany) 27th December, 1937.

523 068.—Means for preventing the false operation of a calling relay in a carrier-wave telephony system.

Philips' Lamp Co. Convention date (Germany) 27th December, 1937.

523 069.—Means for reducing the spacing of the individual carrier-waves, and therefore the cost of the cable, on a multi-channel wired-wireless telephony system.

Philips' Lamp Co. Convention date (Germany) 27th December, 1937.

523 263.—System of distributing television signals, or multiple telegraphy or telephony signals, by periodic impulses.

P. M. G. Toulon. Convention date (France) 5th January, 1938.

CONSTRUCTION OF ELECTRONIC-DISCHARGE DEVICES

521 813.—Cantilever method of mounting and spring-tensioning the cathode or filament of a directly or indirectly heated valve.

Standard Telephones and Cables and T. C. Black. Application date 25th November, 1938.

521 872.—Pentode type of valve with a further auxiliary electrode, beyond the suppressor grid, for the purpose of introducing reaction.

Kolster-Brandes and C. E. Brigham. Application date 29th November, 1938.

522 238.—Construction and arrangement of the glass base and lead-in wires of an electric discharge tube.

Philips' Lamp Co. Convention date (Netherlands) 8th January, 1938.

522 360.—Construction and arrangement of the electrodes in a magnetron tube for generating ultra-short waves.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon). Convention date (France) 3rd February, 1938.

22 359.—Electron-multiplier in which the surface of the tube near the target electrodes is made conductive, in order to facilitate stabilised control of the electron stream.

Standard Telephones and Cables (assignees of Le Matériel Téléphonique Soc. Anon). Convention date (France) 29th January, 1938.

522 496.—Means for reducing thermal "noise" in a valve by confining the working stream to selected electrons within a predetermined range of velocity.

Marconi's W.T. Co. and D. A. Bell. Application date 13th December, 1938.

522 952.—Construction and close-spacing of the electrodes forming the "gun" of a cathode-ray tube.

F. H. Nicoll. Application date 20th December, 1938.

523 307.—Arrangement and assembly of the lead-in wires in a valve for handling ultra-short waves.

The M-O Valve Co. and J. Bell. Application date 30th December, 1938.

523 329.—Magnetron valve fitted with electrodes of high magnetic permeability for concentrating the flux mainly around the cathode or anode.

Marconi's W. T. Co. (assignees of E. G. Linder). Convention date (U.S.A.) 30th December, 1937.

523 352.—Mount or holder affording a low-impedance connection to the electrodes of an ultra-short-wave valve.

Marconi's W.T. Co. (assignees of F. C. Blancha). Convention date (U.S.A.) 31st December, 1937.

SUBSIDIARY APPARATUS AND MATERIALS

521 339.—Magnetic coil arrangement, with valve relay, for detecting the passage of traffic, or of articles on a conveyor band.

Automatic Signal Corporation. Convention date (U.S.A.) 14th August, 1937.

521 713.—Electro-magnetic relay with small capacity between the contacts, particularly suitable for ultra-short-wave wireless equipment.

Standard Telephones and Cables ; R. St. G. Terry ; and J. R. Beard. Application date 22nd November, 1938.

521 862.—High-frequency tuning coil, with the windings arranged in binocular fashion, and with movable iron cores entering opposite ends of the windings.

Johnson Laboratories Inc. (assignees of W. A. Schaper). Convention date (U.S.A.) 26th November, 1937.

521 941.—Control circuit for a gas-filled relay valve fed from A.C. mains.

A. A. Thornton (communicated by Philco Radio and Television Corporation). Application date 26th August, 1938.

521 942.—Means for rapidly heating the cathode of a thermionic valve, particular one used for intermittent duty.

A. A. Thornton (communicated by Philco Radio and Television Corporation). Application date 26th August, 1938.

522 574.—Radio "altimeter" for determining the elevation of an aeroplane by comparing the phase of an outgoing wave and its reflected counterpart.

Standard Telephones and Cables (assignees of A. Alford). Convention date (U.S.A.) 10th December, 1937.

Abstracts and References

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For the information of new readers it is pointed out that the length of an abstract is generally no indication of the importance of the work concerned. An important paper in English, in a journal likely to be readily accessible, may be dealt with by a square-bracketed addition to the title, while a paper of similar importance in German or Russian may be given a long abstract. In addition to these factors of difficulty of language and accessibility, the nature of the work has, of course, a great influence on the useful length of its abstract.

PROPAGATION OF WAVES

3718. Propagation of Electromagnetic Waves inside a Cylindrical Metal Tube and along Other Types of Guides [Discussion based on Theory of Complex Functions: Problems arising in Practical Applications: etc.].—Hsü Chang Pen [C. P. Hsu]. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 193: *Proc. Inst. Rad. Eng.*, June 1940, p. 283: summaries only.)

3719. Research on Wave Guides and Electromagnetic Horns: Report IV.—Sonada. (*See* 3833.)

3720. Ultra - High - Frequency Propagation through Woods and Underbrush [Tests on 500 & 250 Mc/s: Considerable Attenuation, Greater in Summer (Green Foliage): Slight Superiority of Horizontal Polarisation, at Any Rate in Winter: Reflection or Absorption ?].—B. Trevor. (*R.C.A. Review*, July 1940, Vol. 5, No. 1, pp. 97–99.)

3721. Two-Way Telephonic Communication over 90 Miles with Ultra-Short Waves [1.3 m].—Mt. Washington Observatory. (*Sci. News Letter*, 27th July 1940, Vol. 38, No. 4, p. 59.)

3722. Interference between Television (and Sound) Signals from Philco (Philadelphia) and C.B.S. (New York) Stations, separated by 90 Miles.—(*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, p. 207: paragraph only.)

3723. Distance Measurements by Wireless [Description of Systems using Cathode-Ray Oscillographs as Indicators].—(*Sci. Abstracts*, Sec. B, 25th July 1940, Vol. 43, No. 511, p. 310.)

3724. Correction to Equation in "A General Radiation Formula."—Schelkunoff. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 277.) *See* 108 of January.

3725. Wave Reflections at Oblique Incidence [Inversion Layers in Troposphere (1–10 km Heights) causing Short-Wave Reflections: Application of Maxwell's Equations gives Relation in Fair Agreement with Observations].—C. D. Thomas & R. C. Colwell. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, pp. 203–204: summary only.) *See* also 1305 of April.

3726. On the Propagation of the Waves sent out by a Vertical Transmitter in an Atmosphere whose Dielectric Constant and Conductivity depend on the Height.—G. Grünberg. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 6, Vol. 26, 1940, pp. 573–577: in German.)

The Maxwell equations for an isotropic non-magnetisable medium, whose ϵ and σ vary with position but not with time, are given by (1). Limiting the case to sinusoidal oscillations, and assuming the condition that

$$\phi = -(i\omega/ca^2)\,\text{div}\,\vec{A},\; a^2 = i\omega\,(i\omega\epsilon + 4\pi\sigma)/c^2,$$

it follows that the Maxwell equations are fulfilled if $\vec{A}$ satisfies the equation

$$\Delta\vec{A} - a^2\vec{A} - (\text{div}\,\vec{A})\,\text{grad}\,(\log a^2) = -(4\pi/c)\vec{j}^{(e)} \ldots (4),$$

where $\vec{j}^{(e)}$ represents the density of the currents whose distribution in space is supposed to be given at any moment. If ϵ and σ are independent of position, this equation (4) changes into the usual equation for $\vec{A}$. For a variable a^2 the solution of (4) is complicated not only by the fact that its coefficients are no longer constant but also by the appearance of the term containing the divergence of $\vec{A}$, which in general hinders a direct splitting of (4) into separate equations for the individual components of $\vec{A}$. In certain special cases, however, this last condition does not arise: as for example when ϵ and σ depend only on one single co-ordinate (for instance on z), while the currents $\vec{j}^{(e)}$ are parallel to the z axis.

In this case (which includes the problem set out in the title) eqn. 4 is satisfied by putting $A_x = A_y = 0$, $A_z = A$, where A has to satisfy eqn. 5. Assuming vertical transmission (parallel to z) and a field which has rotational symmetry about the axis of the transmitter, the conversion of eqn. 5 into cylindrical coordinates gives eqn. 6. If the currents $j^{(e)}$ are confined within a limited space of finite thickness, eqn. 6 yields eqn. 8; this can be written as in eqn. 9, which is an ordinary inhomogeneous linear differential equation of the second order with variable coefficients, and so belongs to a class whose theory has been well developed.

To illustrate the general method, the writer first considers (on pp. 575–576) the two classic problems of the calculation of the field of a vertical transmitter which is above a perfectly conducting earth and surrounded by a homogeneous atmosphere, and of the same calculation when the earth is taken to have a finite conductivity (Sommerfeld problem). In both these cases a^2 is a constant: section 4 deals with a medium where a^2 is dependent on z, and briefly touches on the three special cases where $f\ (= 1/a^2)$ is equal to $\alpha + \beta z$, $\alpha(z - h)^2$, and $\alpha + \beta e^{-mz}$ respectively. It is proposed to go more deeply into these cases in a later paper.

3727. Collecting Short-Wave Data : Long Period Observations of Propagation Conditions [including the Writer's Observations, 1937/1940].—D. W. Heightman. (*Wireless World*, Aug. 1940, Vol. 46, No. 10, pp. 355–356.)

3728. Developments in Meteorological Sounding by Radio Waves [Small Pulse Transmitter & Receiver : Comparison of Preliminary Data with Radiosonde & Aeroplane-Flight Results].—A. W. Friend. (*Journ. of Aeronaut. Sciences*, June 1940, Vol. 7, No. 8, pp. 347–352.)

3729. The Ionosphere [Survey of Current Facts & Theories].—K. K. Darrow. (*Elec. Engineering*, July 1940, Vol. 59, No. 7, pp. 272–283.) Lecture to the AIEE New York Section. For a fuller version see *Bell S. Tech. Journ.*, July 1940, pp. 455–488.

3730. The Variation in Intensity of Radio Signals [from Near-By Broadcasting Stations, at Mid-Day : Winter Signals Much Stronger than Summer : also Day-to-Day Variation with Changing Weather Cycle].—R. C. Colwell. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 204 : summary only.)

3731. 27-Day Rotation Period found in Weather [Changing Pattern of Air Currents, due to Unequal Distribution of Sunspots].—H. H. Clayton. (*Sci. News Letter*, 6th July 1940, Vol. 38, No. 1, p. 8.)

3732. Sunspots and Magnetic Storms during the Last Week of March, 1940 [Kodaikanal Solar Physics Observatory, Data & Deductions].—M. Salaruddin & C. K. Anantha Subrahmanyam. (*Sci. & Culture*, Calcutta, June 1940, Vol. 5, No. 12, pp. 775–776.)

" From these observations, it is not possible to conclude that either the spot group or the eruptions that it gave rise to are entirely responsible for the magnetic storms and the radio disturbances experienced during the period under consideration. . . . One is forced to the belief that the active agent linking the effects on the sun with the terrestrial disturbances originates in an affected region lying beneath the spot " [*cf.* earlier paper, 2517 of July].

3733. Solar-Radiation Cycles and the Sunspot Period [Ten Regular Cycles, Six at least Closely Related to the 11-Year Period].—T. E. Sterne & others. (*Science*, 19th July 1940, Vol. 92, Supp. p. 9.)

3734. Measurements of the Ultra-Violet Radiation from the Sun in Stockholm [by Photoelectric and Photochemical Methods].—F. Lindholm & G. Cronheim. (*Arkiv för Mat., Astron. och Fysik*, Stockholm, No. 2, Vol. 27B, 1940, pp. 1–5 : in German.)

3735. The Study of the Sun [American Observations This Summer to be made with Skellett Coronaviser and by Lyot Method (with Innovation of Non-Reflecting Treatment of Lens Surfaces) : etc.].—J. Stokley. (*Science*, 5th July 1940, Vol. 92, Supp. p. 8.)

3736. Influence of Lunar Periodicity on Climate according to O. Pettersson [from 160 Years' Winter-Temperature Data : 11.1-Year Sunspot Period (more regular than Sunspots Themselves) : 9-Year Lunar Node-Apside Period clearly Evident : Resulting 45-Year Period : etc.].—C. Benedicks. (*Arkiv för Mat., Astron. och Fysik*, Stockholm, No. 7, Vol. 27A, 1940, pp. 1–15 and Plate : in English.)

3737. Temporal Effects in Nitrogen Afterglows, *and* Afterglows in Nitrogen-Helium Mixtures.—J. Kaplan & S. M. Rubens. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 188 : p. 188 : summaries only.)

3738. New Studies on Active Nitrogen : I & II.—Rayleigh. (*Proc. Roy. Soc.*, Ser. A, 18th July 1940, Vol. 175, No. 963, pp. S40–S41 : abstracts only.) " The amount of energy collected from the gas was surprisingly large, and is difficult to reconcile with existing theories of the nature of active nitrogen."

3739. Telescopic Meteors [Estimation of Number entering Atmosphere Each Day], *and* Seasonal Variation in the Height of Meteors.—F. Watson : R. A. McIntosh. (*Sci. Abstracts*, Sec. A, 25th July 1940, Vol. 43, No. 511, p. 526 : p. 527.) For another summary of McIntosh's paper see *Nature*, 24th Aug. 1940, Vol. 146, p. 271.

3740. A New Type of Variation in Cosmic Radiation [Large Fluctuations of Ratio Intensity-from-North/Intensity-from-South : due to Some Atmospheric Asymmetry ?].—H. Alfvén. (*Arkiv för Mat., Astron. och Fysik*, Stockholm, No. 1, Vol. 27B, 1940, pp. 1–6 : in English.)

3741. Further Investigations of Air-Mass Effect on Cosmic-Ray Intensity.—D. H. Loughridge & P. F. Gast. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, pp. 194–195: summary only.) *See* also 2874 of August, and *cf.* 3314 & 3315 of September.

3742. Radio-Frequency Measurements of Ground Conductivity in Canada [from Field-Strength Surveys for Broadcasting Purposes, using Eckersley's Approximation to Sommerfeld's Formula: Comparison of Conductivity Map and Geological Map: Correlation employed in Estimation of Field-Strength Contours].—K. A. MacKinnon. (*Canadian Journ. of Res.*, July 1940, Vol. 18, No. 7, Sec. A, pp. 123–131.) *See* also 3471 of 1939 and 2906 of August.

3743. The Diffraction of a Plane [Elastic] Wave by a Circle: *also* On the Distribution of Waves in Space of Three Dimensions: *and* The Resolution of the Exterior Problem of Cauchy-Dirichlet for a Wave Equation in the Case of a Sphere.—J. A. Mindline. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 6, Vol. 26, 1940, pp. 556–560: pp. 561–565: pp. 566–569: all in French.)

3744. The Derivation of Formulae for determining the Travelling Wave when Telemechanical Signals are transmitted over a Line.—V. I. Kovalenkov. (*Automatics & Telemechanics* [in Russian], No. 6, 1939, pp. 3–16.)

It is pointed out that the general solutions (2) and (3) of the telegraph equations (1) of a transmission line are of a little value for practical purposes, and that particular solutions have so far been found only for the cases when the distant end of the line is either open or short-circuited. In the present paper a mathematical analysis is given of the propagation of a wave along an infinite line, and equations determining the voltage and current in the line are derived (top of p. 10). It is shown that by using this method solutions can be found for any finite line, and in particular for a line loaded with an electro-magnetic receiver. The actual transition from an infinite to a finite line will be discussed in a separate paper.

3745. On the Propagation of H.F. Electromagnetic Energy along Symmetrical Multi-Conductor Lines.—V. A. Dyakov. (*Automatics & Telemechanics* [in Russian], No. 6, 1939, pp. 17–28.)

In connection with the transmission of signals over high-voltage lines, the relationships between the voltage and current at the sending and receiving ends of the lines are established (eqn. XXIII) for the case of a three-phase line with the source of energy connected between one phase and earth (Fig. 1).

3746. A Possible Explanation of Deep-Focus Earthquakes [Parabolic Mirror formed by Mountain Roots].—J. Lynch. (*Science*, 5th July 1940, Vol. 92, pp. 10–11.)

ATMOSPHERICS AND ATMOSPHERIC ELECTRICITY

3747. Atmospherics of Distant Origin [Dacca Measurements on 150–800 m, June 1939].—S. R. Khastgir & A. K. Ray. (*Sci. & Culture*, Calcutta, June 1940, Vol. 5, No. 12, pp. 772–773.)

For "distant" (*i.e.* not local and not extra-terrestrial) atmospherics received in the daytime, the field strength varied nearly inversely as the square of the frequency: this relation did not hold for night observations, no doubt owing to reflection from the ionosphere. The day results indicate that the attenuation varied only slightly with frequency, over the range of wavelengths employed. The inverse-square relation has already been reported for the rainy season (1329 of April, Chakravarti & Ghosh). The value of the field strengths of the atmospherics rose in the afternoon, with a maximum about sunset and a sharp decrease to a minimum soon after sunrise, followed by a gradual rise to a maximum an hour or two after sunrise: Potter's similar results and his interpretation of them (1932 Abstracts, p. 31) are considered.

3748. The Sparking Threshold in Air [Measurements to test Streamer Theory of Breakdown (Loeb & Meek): Marked Effect of Previous Sparks on Threshold: etc.].—W. R. Haseltine. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 188: summary only.) *See*, for example, 3339 of September, and below.

3749. Theoretical Calculations of Breakdown Potential for Sphere Gaps [Streamer Theory], *and* The Variation of Sparking Potential with Dense Initial Photoelectric Currents.—J. M. Meek. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 195: p. 196: summaries only.) *See* also 3339 of September.

3750. The Mechanism of Electrical Discharges in Gases of Low Pressure [Survey, with 339 Literature References].—Druyvesteyn & Penning. (*Reviews of Mod. Physics*, April 1940, Vol. 12, No. 2, pp. 87–174.)

3751. The Magnetic Surge Integrator, the Fulchronograph, and the Magnetic Surge-Front Recorder.—C. F. Wagner & G. D. McCann. (*Science*, 5th July 1940, Vol. 92, Supp. pp. 8 and 10.)

3752. Radio Direction-Finding for Meteorological Balloons at 1.67 Metres.—L. C. Yuan & S. S. Mackeown. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 286: summary only.) *See* also 3041 of August.

3753. "Physics of the Earth: Vol. 7—Internal Constitution: Vol. 8—Terrestrial Magnetism and Electricity" [Book Reviews].—Gutenberg (Edited by). (*Nature*, 10th Aug. 1940, Vol. 146, pp. 181–182: 13th Jan. 1940, p. 47.)

PROPERTIES OF CIRCUITS

3754. Lines with Non-Uniformly Distributed Parameters [and Their Advantages as Impedance Transformers, etc.].—Volpert. (*See* 3835.)

3755. Concentric-Line Resonator Filter Circuits for Ultra-High Frequencies.—R.C.A. (*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, pp. 209 and 211.) Abstract of a recent patent.

3756. Multi-Stage Standing-Wave Circuits [and Their Merits, Electrical or Acoustical].—K. Okabe. (*Electrotech. Journ.*, Tokyo, June 1940, Vol. 4, No. 6, p. 142.)

In the simple case now considered, the circuit consists of four stages in series, all of a quarter-wavelength but of two different surge impedances Z_1 and Z_2. Starting at the left (input) end we have circuit 1 with Z_1, then circuit 2 with Z_2, then circuit 1′ with Z_1 again, followed by circuit 2′ (at output end) with Z_2. This arrangement and its modifications have certain advantages: thus "equations 2 to 4 suggest the possibility of obtaining a powerful frequency stabiliser."

3757. High-Gain Amplifier for 150 Megacycles [Frequency reduced by about 10 Mc/s at End of First 5 Stages (out of 10)].—Rodwin & Klenk. (*See* 3801.)

3758. Voltage Dividers for Extended Frequency Ranges [in Television, etc.].—F. A. Everest. (*Communications*, May 1940, Vol. 20, No. 5, pp. 8–9 and 22, 23.)

3759. A New Method of Logarithmic Rectification [Rectification Characteristic of Multi-Grid Valve changed from Almost Perfect Linear Shape to Almost Perfect Logarithmic by Slight Change of Grid-Bias Voltage: Uniformity at the Higher Frequencies better than with Copper-Oxide Rectifier: Simpler than Rectifier with Rectified Feedback].—T. Hayasi & S. Akasi. (*Electrotech. Journ.*, Tokyo, June 1940, Vol. 4, No. 6, p. 141.)

3760. Further Applications of Space-Charge Coupling [particularly to Condenser-Microphone Amplification (with Very Good Signal/Noise Ratio & Other Advantages), Ultra-Micrometer Circuits, etc.].—J. A. Sargrove. (*E. & Television & Short-Wave World*, April 1940 Vol. 13, No. 146, pp. 192 & iii: summary only.)

Continuation of the work dealt with in 971 of March. A change of $10\,\mu\mu$F in capacity can produce a current change of as much as 5 mA.

3761. Some Notes on Linear and Grid-Modulated Radio-Frequency Amplifiers [Performance made Almost Perfect by Balanced Feedback].—Terman & Buss. (*See* 3794.)

3762. On Choosing the Optimum Operating Conditions for the Final Stage of an L.F. Amplifier, taking into Account the Non-Linearity of Valve Characteristics.—C. N. Krize. (*Elektrosvyaz*, No. 2, 1940, pp. 71–75: Russian only.)

It is pointed out that in amplifiers with negative feedback, where the distortion introduced is not so important, it is desirable to obtain the highest possible power output. Accordingly a method is proposed for determining the load necessary for obtaining $P_{1\,\max}$ from a triode or a pentode for a given anode voltage E_a. Equation (1) of the anode-current/anode-voltage characteristic corresponding to zero grid voltage is written down, and values of the coefficients a and p of the equation for various types of valve are shown in table 1 on p. 74. Equation (3) is derived determining the power output P_1 as a function of ξ (ratio of peak anode-voltage swing to steady anode voltage) and the optimum value of ξ is found ($= 1/(p+1)$: eqn. 5). Formula (5) enables the optimum load to be determined for any shape of the valve characteristic, and a graphical method is suggested for the case of a pentode (Fig. 6). Curves are plotted to simplify the necessary calculations, and formula (6) is derived for determining $P_{1\,\max}$. For the case when, instead of E_a, the maximum anode dissipation $P_{a\,\max}$ is specified, the corresponding formulae are derived on p. 75.

3763. Feedback [General Survey: Effects of Negative Feedback in reducing Distortions: in modifying Input & Output Impedances (Parallel Feedback, Current Feedback): Prevention of These Modifications, and of Phase Shifts, by Bridge Circuits: Stability Conditions (with Simple "Pi-Attenuation" Rule): Practical Circuits (Cathode Follower, etc.): Phase-Shift Measurement: etc.].—E. K. Sandeman. (*Wireless Engineer*, Aug. 1940, Vol. 17, No. 203, pp. 342–353.)

3764. Negative-Feedback Amplifiers: Problems of Stabilisation.—(*Wireless World*, Sept. 1940, Vol. 46, No. 11, p. 389.)

3765. Negative Feedback Applications: I [General] & II [Selective L.F. Amplifiers (using Bridge Circuits) and Oscillators].—C. Lockhart. (*E. & Television & Short-Wave World*, April & May 1940, Vol. 13, Nos. 146 & 147, pp. 161–163 & 221–223.)

3766. Negative Feedback applied to Oscillators [for Frequency Stabilisation by "Discriminator" (A.T.C.) Circuit: Application as Source of Frequency-Modulated Signals].—S. Sabaroff. (*Electronics*, May 1940, Vol. 13, No. 5, pp. 32–33.) For previous work *see* 1859 & 2881 of 1939.

3767. Versatile Oscillator—the Numans [and Transitron] Circuit.—Cocking. (*See* 3792.)

3768. Hum-Neutralising Circuit for Use with the Augetron.—Vacuum Science Products. (*See* 3855.)

3769. On Possible New Properties of Chain Filter Circuits.—V. N. Listov. (*Automatics & Telemechanics* [in Russian], No. 6, 1939, pp. 61–66.)

"T" and "pi" filters are derived (Figs. 5 & 7) equivalent to the lattice type (Fig. 1), *i.e.* the attenuation of these filters is made independent of the characteristic impedance.

3770. " RUNDFUNKSIEBSCHALTUNGEN " [Broadcast Filter Circuits: Book Review].—R. Feldtkeller. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 289.)

3771. THE " TRANSDUCER " AND ITS APPLICATIONS [Combination of Two Single-Phase Iron-Cored Transformers to form a D.C. Operated A.C. Relay, Amplifier, Control Device, etc: Study of Its Behaviour].—U. Lamm. (*Rev. Gén. de l'Élec.*, 25th May/1st June 1940, Vol. 47, No. 21/22, pp. 373–389.) Translated from the paper in English in *ASEA Journal*, May/June 1939. In a self-exciting connection the arrangement will give an amplification of the order of 400 000.

3772. MECHANISM OF OPERATION OF MULTIVIBRATOR [Experimental Study and Theoretical Conclusions].—M. Hukata & M. Orihara. (*Electrotech. Journ.*, Tokyo, June 1940, Vol. 4, No. 6, pp. 142–143.)

" The main point of discussion lies in the fact that the principal cause of this mechanism of operation is in the discharging circuit. From this the phenomena in the case of unsymmetrical construction of circuit constants may be readily assumed, which was very difficult to be solved by any analytical methods of solution for the operation of a multivibrator."

3773. VARISTORS: THEIR CHARACTERISTICS AND USES [particularly in Telephone System: Rectifiers, Thyrite Varistors, & Thermistors].—J. A. Becker. (*Bell Lab. Record*, July 1940, Vol. 18, No. 11, pp. 322–327.) *Cf.* 3359 of September, and below.

3774. A THERMISTOR VOLTAGE-REGULATOR.—C. B. Green & G. L. Pearson. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 204: summary only.) *See* also 3359 of September, and above.

3775. VOLTAGE CONTROL WITH A NON-LINEAR WHEATSTONE BRIDGE [with Two Incandescent Lamps].—W. Richter. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 20–21 and 108.)

TRANSMISSION

3776. ON THE THEORY OF TRANSIT-TIME OSCILLATIONS [Retarding-Field & Magnetron Oscillations treated on the Retroaction Principle].—F. Lüdi. (*Helvetica Phys. Acta*, Fasc. 2, Vol. 13, 1940, pp. 77–121.)

For previous work, on Posthumus oscillations in the magnetron, *see* 3265 of 1937. From the author's summary:—" The transit-time oscillations are regarded as a coupled system of oscillating space charge and electrical oscillatory circuit. The differential equations obtained for this system show a formal analogy with those of the two-circuit transmitter. The solution of the equations for free undamped oscillation gives the coupling-wave and intensity curves of Fig. 3, which agree qualitatively well with experiment.

" With the introduction of back-coupling, the differential equations are extended to those for the self-controlled system, taking the damping into account [§ 5 shows how the electric moment xq of the space charge is diminished by the coupling damping: it must therefore be maintained in a stable condition by a process of self-regulation—§ 6]. The formal introduction of back-coupling is based on the ' sorting-out ' mechanism and the equations of motion for the individual electron. . . . The steady-state solutions for the self-controlled system give, for low damping, the same coupling-wave and intensity characteristics (in particular, the same resonance voltage) as the solutions for the free undamped oscillation. In addition, a typical oscillation-onset condition (formula 79) is obtained for the back-coupled system: this contains also the break-off phenomena. Owing to the limitation [of the whole treatment] to linear systems, this phenomenon is only qualitatively represented; the observed displacement of break-off towards the shorter waves is not shown.

" A more exact investigation of the coupling waves in the case of resonance, taking damping into account, shows that different coupling waves can only appear when the coupling is above a critical value.

" In the stationary régime the phase angle between voltage and oscillating space charge is regulated by the coupling factor, the damping, and the phase of the back coupling relative to the a.c. voltage (' sorting-out ': eqns. 36, 38, & 74) in such a way that phase agreement exists between the existing and the newly arriving space charge.

" The voltage values are, in a first approximation, independent of the damping and agree with those for the free, undamped oscillation. The equations show a relation between the percentage departure of the coupling frequency from the resonance frequency, on the one hand, and the resonance voltage on the other. The voltage value thus calculated agrees with the measured value in order of magnitude (around 20 v). Further, the space-charge density can be determined from the measured coupling factor; an upper limit of 6×10^7 electrons per cm^3 is found. Thus the assumption of free electron paths is largely justified.

" For couplings smaller than the critical there appears, in agreement with certain published experimental results [Groos: Lerbs & Lämmchen: 1820 of 1938, 1408 of 1939], only a single frequency and a single voltage (different from the above): it has a phase displacement of $-90°$ with respect to the oscillating space charge.

" The occurrence of the coupling waves is linked to the condition that the coupling frequency is different from the natural frequency of the electrons. In the retarding-field valve and in the magnetron of Type I (un-split anode) this is actually the case, since the solution of the equations of motion gives a superposition of two oscillations (natural frequency *plus* coupling frequency). In the magnetron oscillations of Type II (split anode) the solution shows a far-reaching synchronisation of the natural frequency with the coupling frequency, and thereby with the frequency of the tuned circuit. With these oscillations, therefore, the coupling effects do not make their appearance, and the tuning is not so sharp as with the above-described oscillations. The synchronisation is also responsible for the relatively high efficiency of the Type II oscillations, since here the electrons always find themselves in the phase for delivering energy, whereas in Type I oscillations their motional phase is continually changing with respect to the voltage. It must be arranged, by the second 'sorting-out' mechanism, that they are removed before the first phase-reversal: this is possible even for quite large amplitudes.

"The various types of modulation [for transmitters], and the possibility of damping reduction [in receivers], are contained implicitly in the damping of the internal system (oscillating space charge), since this can be widely varied by influencing the sorting-out process." The writer's experimental results with various types of magnetron (including Helbig's design with the cathode outside the end of the anode—131 & 2768 of 1938) are discussed in the final section in relation to various points occurring in the theoretical part.

3777. THE ULTRA-SHORT-WAVE GENERATOR WITH PHASE-FOCUSING (KLYSTRON).—F. Lüdi. (*Helvetica Phys. Acta*, Fasc. 2, Vol. 13, 1940, pp. 122–143.)

"Recently a method of h.f. amplification and generation of electromagnetic waves down to about 10 cm, based on the principle of the phase-focusing of a velocity-modulated cathode ray, has become important because of the large outputs thus attained. Theoretical treatments of particular points have been given from various sources. In particular, on the one hand the current modulation has been calculated from the velocity modulation [Varian, 2773 of 1939], and on the other, the phase focal point has been determined in its dependence on alternating potential, accelerating potential, and frequency [Brüche & Recknagel, 2325 of 1938].

"The object of the present investigation is to find a general analytical expression for the modulated current which will embrace both these statements. On the basis of this expression the a.c. potential induced at the inductor [*i.e.* the collector system at the end of the drift tube] by the electron 'bunches' is calculated, and from this the amplification factor. For a back-coupled arrangement an expression is obtained for the condition for the setting-in of oscillations (amplitude and phase conditions). Further, the limiting of the a.c. potential amplitude and the maximum efficiency of the generator are investigated" [for the latter *see* p. 141: the value of 58% obtained "agrees with those found independently by Geiger (2950 of August) and Webster" (3950 of 1939 and 968 of March)].

An additional section deals with the difference between the writer's treatment and that of Webster here referred to; the results also differ in certain points. The writer's treatment brings out the transit-time character in the inductor, leading to eqn. 25 (ratio of inductor thickness to electron passage-time, for optimum working point: inductor thickness d should be an odd multiple of a half "bunch" length: "This condition is equivalent to the requirement that the passage time T' $(= d/v_0)$ should be an odd multiple of half an oscillation period $T/2$.") Thus there are two characteristic passage times, the drift time between modulator and inductor and the transit time of the resulting space charge through the inductor, with its definite relation to the oscillatory-circuit period. This second relation is analogous to that in retarding-field valves and magnetrons. Most writers, on the other hand, treat the inductor as very thin (transit time infinitely small) and only attach importance to the drift time.

3778. CAUSES OF FREQUENCY VARIATIONS IN KLYSTRON OSCILLATORS [Variation with Voltage: Variation with Current, due to Change of Resonator Frequency "arising from Dielectric Constant of Electrons inside": Theory: Practical Cases].—Ginzton & others. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 282: summary only.)

3779. SIMPLE CALCULATIONS OF KLYSTRON EFFICIENCY.—E. U. Condon. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 204: short summary only.)

3780. SOME TYPICAL PHENOMENA RELATING TO ULTRA-SHORT-WAVE [Transmitting] PENTODE AMPLIFIER CIRCUITS [Experimental Results with the New Type PB 3/800, confirming Theoretical Considerations].—K. Posthumus & C. A. Gehrels. (*Philips Transmitting News*, Dec. 1939, Vol. 6, No. 3/4, pp. 49–55.)

Continuation of the work on pentodes at u.h.frequencies dealt with in 3321 of 1937. The point particularly considered is the difficulty, at these frequencies, of obtaining the absence of h.f. voltage on both screen grids, owing to the impossibility of connecting these grids to earth through small impedances: the practice is to include impedances which are adjusted so that no resultant retroaction occurs, but various complications are likely to follow (coupling effects outside the valve, the existence of two degrees of freedom, etc.). It is the behaviour of these impedances in a push-pull circuit, and the obtaining of the necessary stability in a single-valve circuit (where it is no longer possible to connect two points at opposing h.f. potentials *via* suitable impedances), that are investigated in the present paper. A sufficiently stable single-valve circuit for wavelengths down to 6 m is obtained.

3781. ULTRA-HIGH-FREQUENCY POWER [Oscillator delivering 1 kW at 600 Mc/s].—Sloan & Marshall. (*See* 3851.)

3782. MULTI-STAGE STANDING-WAVE CIRCUITS [with Application to Frequency Stablisation and Acoustics].—Okabe. (*See* 3756.)

3783. C.A.A. USE OF COAXIAL WIRES FOR ULTRA-HIGH-FREQUENCY TUNED CIRCUITS.—Civil Aeronautics Authority. (*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, p. 175.)

3784. REACTANCE-TUBE FREQUENCY MODULATORS.—Crosby. (*R.C.A. Review*, July 1940, Vol. 5, No. 1, pp. 89–96.) Already dealt with in 2957 of August.

3785. AMPLITUDE, FREQUENCY, AND PHASE-ANGLE MODULATION.—G.W.O.H. (*Wireless Engineer*, Aug. 1940, Vol. 17, No. 203, pp. 339–341.)

Frequency modulation and phase-angle modulation (if "angular throw" ϕ is small) can be analysed approximately into same carrier and sidebands (except for phase of latter) as amplitude modulation: graphical treatment of p.a. modulation for larger throws: rough approximation for $\phi = \pi/2$, giving five components: relative amplitudes of carrier and sidebands, for $\phi = 0.4 \ldots 4$ (carrier vanishes at about 2.5): application to frequency modulation: in p.a. modulation, sideband amplitudes depend only on ϕ, in frequency modulation also on modulation frequency: Carson's 1922 condemnation of frequency modulation: literature references. *See* also 3786, below.

3786. AMPLITUDE, FREQUENCY, AND PHASE MODULATION [Criticism of Editorial: the Practicability of Duplex Frequency- and Amplitude-Modulation on Same Frequency: Armstrong Wide-Band System is a Combination of Frequency- and Phase-Modulation, requiring a Special Name].—D. Pollack: G. W. O. H. (*Wireless Engineer*, Aug. 1940, Vol. 17, No. 203, p. 353.) *See* 2551 of July. There appears to be a misprint in G. W. O. H.'s reply.

3787. FREQUENCY MODULATION *versus* PHASE MODULATION [Advantages of Phase over Frequency Modulation: Optimum Modulation Index is $K/6$: New Method of Demodulating: etc.].—C. J. Breitwieser. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 282: summary only.) From the de Forest laboratories. *Cf.* 3788, below.

3788. FREQUENCY-MODULATED-WAVE BROADCAST TRANSMITTERS [and the Relative Merits of Phase Modulation and Direct Frequency Modulation: Problems of Circuit Design: Circuit and Performance of 1 kW Transmitter: etc.].—W. R. David. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 282: summary only.) From the General Electric Company. *Cf.* 3787, above.

3789. PERFORMANCE CHARACTERISTICS OF FREQUENCY MODULATION IN ULTRA-HIGH-FREQUENCY SOUND BROADCASTING.—R. F. Guy. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 282–283: summary only.) The NBC transmitter at W2XWG and the investigations carried out with it.

3790. THE PRINCIPLES OF FREQUENCY MODULATION AND THEIR APPLICATIONS TO TRANSMITTERS AND RECEIVERS.—W. A. Roberts. (*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, pp. 203–206.)

3791. BEAT-FREQUENCY CRYSTAL OSCILLATOR: A LONG-WAVE OSCILLATOR USING SHORT-WAVE OSCILLATING CRYSTAL PLATES.—I. Koga & W. Yamamoto. (*Electrotech. Journ.*, Tokyo, June 1940, Vol. 4, No. 6, pp. 134–137.)

Arising out of the work dealt with in 3383 of September. "On account of being unable to get comparatively low frequencies by means of existing crystal oscillators, there have been all kinds of inconveniences. But when a beat-frequency oscillator such as shown in Fig. 1 is used, although all the defects may not be eliminated, frequencies ranging from the audio frequency below 1 kc/s up to the high frequency above 1 Mc/s can be generated quite easily with short-wave crystal plates and a single tube, rendering all sorts of conveniences in practice." The temperature-variation of frequency of the crystals appears, very much magnified, in the beat-frequency output, but "fortunately for the low frequency in general, it is not necessary to limit so strictly the variation of frequency." *Cf.* Bliss & Bailey, 3378 of September.

3792. VERSATILE OSCILLATOR—THE NUMANS CIRCUIT [Negative-Mutual-Conductance Tetrode Circuit, revived, with Pentode, under the Name of "Transitron"]: RF, AF, AND SAW-TOOTH GENERATOR.—W. T. Cocking. (*Wireless World*, Sept. 1940, Vol. 46, No. 11, pp. 390–393.) For papers on the "Transitron" *see* 2296 of 1939 and back reference. The present writer pays particular attention to the use as a saw-tooth generator.

3793. GENERATION OF SQUARE-WAVE VOLTAGES AT HIGH FREQUENCIES.—W. H. Fenn. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 282: summary only.)

Another summary was dealt with in 563 of February. Still squarer waves are produced by a third system, which is a combination of the two there mentioned.

3794. SOME NOTES ON LINEAR AND GRID-MODULATED RADIO-FREQUENCY AMPLIFIERS [Performance made Almost Perfect by Balanced Feedback ("Remodulation" System of Feedback, applicable to Individual Stages): and an Arrangement allowing Grid-Modulated Amplifier to be operated in Positive-Grid Region].—F. E. Terman & R. R. Buss. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 285: summary only.)

3795. A NEW COIL-COUPLING SYSTEM [in Transmitting Circuits: Direct Mutual Inductance aided or opposed by Movable Low-Inductance "Link" Circuit].—R.C.A. (*E. & Television & Short-Wave World*, July 1940, Vol. 13, No. 149, p. 302.)

3796. A 500-KILOWATT HIGH-EFFICIENCY BROADCAST TRANSMITTER [in Mexico: Doherty Circuit: New 250-Watt Valves].—J. O. Weldon. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 285–286: summary only.)

3797. THE DOHERTY SYSTEM FOR THE AMPLIFICATION OF MODULATED OSCILLATIONS.—G. M. Drabkin. (*Elektrosvyaz*, No. 2, 1940, pp. 22–39: Russian only.) A general discussion of the operation of the system, including design considerations and practical operating conditions.

3798. LONG-WAVE C.W. TRANSMITTER TYPE KSVC 20/11 [only 4 Stages, thanks to Modern Pentodes in H.F. Amplifying Stages: for High-Speed Working].—(*Philips Transmitting News*, Dec. 1939, Vol. 6, No. 3/4, pp. 56–58.)

3799. Radio-Frequency Spark-Over in Air [Measurements at 700 kc/s and 1.8 Mc/s, using Various Electrodes: Tests on Air Condensers show Optimum Plate Thickness to be from One Half to One Third of Air Gap].—P. A. Ekstrand. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 262–266.) A summary was dealt with in 556 of February.

RECEPTION

3800. Panoramic Reception [for Navigation, etc.].—Wallace. (*See* 3888.)

3801. High-Gain Amplifier for 150 Megacycles [Over-All Gain of 114 db and Transmitted Band of over 2 Mc/s (for Television, Frequency Modulation, etc.): Output of 2.5 W with Signal/Distortion Ratio of 60 db: Frequency reduced by about 10 Mc/s at End of First 5 Stages (out of 10): Filter-Type Inter-Stage Couplings].—G. Rodwin & L. M. Klenk. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 257–261.)

Used (*e.g.*) by Schafer & Goodall in their measurements of atmospheric noise (2688 of 1939). The first 5 stages have acorn valves, the last 5 a medium-powered experimental type (Western Electric 240 HH, a push-pull pentode with an operating plate dissipation of 30 watts).

3802. Ultra-High-Frequency Oscillator Frequency-Stability Considerations [Drift in U.H.F. Receivers: Examination of Causes, particularly the Change of Inductance with Change of Temperature: Design of Formers, & Use of Copper-Plated Invar or Nilvar Wire: Humidity: Compensation for Variations in Operating Parameters: Oscillator Circuit based on These Considerations: etc.].—S. W. Seeley & E. I. Anderson. (*R.C.A. Review*, July 1940, Vol. 5, No. 1, pp. 77–88.)

3803. Narrow-Band *versus* Wide-Band in Frequency Modulation Reception.—Levy. (*See* 4078.)

3804. Frequency-Modulation Receiver Design [Principles of Design, illustrated by General Electric Models HM-80 & HM-136].—R. F. Shea. (*Communications*, June 1940, Vol. 20, No. 6, pp. 17–23.)

3805. Designing a Wide-Range Ultra-High-Frequency Receiver: Circuit Features of a Frequency-Modulation/Amplitude-Modulation Receiving System.—F. W. Schor. (*QST*, Aug. 1940, Vol. 24, No. 8, pp. 34–37 and 85, 86.)

3806. The Principles of Frequency Modulation and Their Application to Transmitters and Receivers.—W. A. Roberts. (*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, pp. 203–206.)

3807. "An Introduction to Frequency Modulation" [for Service Men: Book Review].—J. F. Rider. (*Communications*, July 1940, Vol. 20, No. 7, p. 11.)

3808. Artificial-Lightning Plant [producing Visible & Noisy Corona] used to test Interference-Proof Performance of Frequency Modulation.—General Electric. (*Electronics*, May 1940, Vol. 13, No. 5, pp. 46..50.)

3809. Frequency Modulation and Interference [Editorial Comment].—(*Wireless World*, Sept. 1940, Vol. 46, No. 11, p. 381.)

"We must face the fact that if high-fidelity broadcasting is to be open to the majority of the population after the war, it will only be obtained by the use of frequency modulation. . . . We consider that those who demand high-quality reproduction form the backbone of the listening public." *See* also p. 410.

3810. Effect of Radio-Interference Suppressors on Engine Performance [Adverse Effect on Some Overhead-Valve Engines at Low Speeds, due to Insufficient Turbulence: etc.].—(*Automobile Engineer*, June 1940, Vol. 30, No. 398, pp. 167–173.) The suppressors were 10 000–15 000 ohm resistances, in each h.t. lead. *Cf.* 980 of March and 2982 of August.

3811. Field-Strength Measuring Equipment at 500 Megacycles [used in Ignition-Interference Investigations].—George. (*See* 3973.)

3812. Analysis of the Interference Protection of Series Motors by means of Condensers [including Calculation of "Protection Factor" and Comparison with Measured Values: Protection may cause Worse Interference: etc.].—E. T. Glas. (*Sci. Abstracts*, Sec. B, 25th July 1940, Vol. 43, No. 511, p. 327.)

3813. Radio Interference [Its Propagation: Suppression at Receiver: at Source (Commutator Motors, Switching Devices, Osira Lamps, Neon Signs—Lovell Foot's Choke): Iron-Cored Chokes (with References to B.E.I.R.A. Reports): etc.].—N. R. Bligh & R. F. Proctor. (*G.E.C. Journ.*, Feb. 1940, Vol. 11, No. 1, pp. 55–65.)

3814. Anti-Interference Data: E.R.A. Reports [List].—Electrical Research Association. (*Wireless World*, Aug. 1940, Vol. 46, No. 10, p. 359.)

3815. "Keyed" Diathermy-Interference identified at Distances of Thousands of Miles.—(*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, p. 165: paragraph only.)

3816. Reducing [Man-Made] Interference: Methods applicable to the Receiver ["a Discussion, backed up by the Results of Practical Tests," of the Various Circuits operating by "Punching a Hole of Silence" in the Received Signal].—R. I. Kinross. (*Wireless World*, Sept. 1940, Vol. 46, No. 11, pp. 382–385: to be contd.) *See*, for example, Lamb, 2162 of 1936.

3817. Cross Modulation: Its Effects in Different Stages of a Receiver: the Cure.—"Codon." (*Wireless World*, Aug. 1940, Vol. 46, No. 10, pp. 352–354.)

3818. Neutralising Screened-Grid Valves [to overcome Tendency to Instability in Specially Good Circuits, without Nullifying this Goodness: Difficulties with Ordinary Neutralising Condensers: Variable Condenser formed by Earthed Screen, with Adjustable Aperture between Grid Electrode & Anode Electrode or Anode Itself].—V. O. Stokes. (*Wireless Engineer*, Aug. 1940, Vol. 17, No. 203, pp. 354–355.)

3819. Bass Compensation by Screen-Grid Injection ["Syncrotronic" System, avoiding Boomy Speech Reproduction but giving "Richness" of Bass, using Multi-Grid Valve in First A.F. Stage: 25 db Gain at 75 c/s, dying away to Zero at 150 c/s].—L. M. Barcus. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 44 . . 48.) Working well even at very low volume levels.

3820. Non-Stationary Processes in Receivers with Automatic Tuning.—V. I. Siforov & G. V. Gitshov. (*Elektrosvyaz*, No. 2, 1940, pp. 7–21: Russian only.)

The operation of a discriminator of the type proposed by Foster & Seeley (Fig. 1: 2543 of 1937) is discussed, and this discussion is followed by a mathematical analysis of transient phenomena in a receiver before stabilised conditions are reached, when (a) no a.v.c. is used and a two- or three-section filter is connected between the discriminator and the control valve (Fig. 5); (b) a separate diode is used for a.v.c. (Fig. 7); and (c) the same diode is used for automatic tuning and a.v.c. (Fig. 8). The conclusions reached are as follows:—(1) Filters connected between the discriminator and the control valve should not have more than two sections; (2) a separate diode should be used for a.v.c.; and (3) in a broadcasting receiver a one-section filter should be used in the a.v.c. circuit, and a two-section filter, with time constants differing by from 5 to 10 times, in the discriminator circuit. A short report on experiments confirming the theoretical conclusions is included.

3821. A Simplified Multiple Scale for Measuring Instruments [and Radio Receivers, etc.]: the Rotoroid Rotating Scale.—(*Electronics*, June 1940, Vol. 13, No. 6, p. 99.)

3822. Short-Wave Auto Radio [particularly the Philco Three-Band Car Receiver Model AR9, up to 12.1 Mc/s].—R. G. Herzog. (*Communications*, July 1940, Vol. 20, No. 7, p. 9.) Karadio offers a choice going up to 44 Mc/s.

3823. Marconiphone Model 895: a New Battery Portable with Push-Button Tuning [and Special Helical Medium-Wave Frame Aerial (Pick-Up Efficiency claimed to be Twice the Normal)].—(*Wireless World*, Aug. 1940, Vol. 46, No. 10, p. 373.)

3824. Marconiphone Model 911: a New AC Receiver of Unconventional Design.—(*Wireless World*, Sept. 1940, Vol. 46, No. 11, p. 411.)

3825. The "Navigator Globe Radio" [Broadcast Receiver in Mounted Globe].—Mitchell Mfg. Co. (*Communications*, July 1940, Vol. 20, No. 7, p. 14.)

3826. Test Reports: Murphy A92 "Stationmaster" [with Band Spreading on Short-Wave Range], *and* G.E.C. Portable BC 4141 [All-Dry," with Rubber-Sprung Chassis].—(*Wireless World*, Aug. 1940, Vol. 46, No. 10, pp. 367–368.) For a correction to the latter report see *ibid.*, September, p. 394.

3827. Test Reports: H.M.V. Model 1406 [High-Grade Battery Portable with Push-Button Tuning], *and* Cossor Model 55 [All-Dry Transportable 4-Valve Superheterodyne].—(*Wireless World*, Sept. 1940, Vol. 46, No. 11, pp. 401–402: pp. 406–407.)

3828. Additions to the Cossor Range: Table Model 34, [Battery-Operated Three-Waveband] and Models 47 & 77 [Mains-Driven].—(*Wireless World*, Sept. 1940, Vol. 46, No. 11, p. 407.)

3829. "Mallory-Yaxley Radio Service Encyclopedia, 3rd Edition" [with Data on 22 000 Receivers: Book Review].—(*Communications*, June 1940, Vol. 20, No. 6, p. 25.)

3830. Checking and Overhauling Communication Receivers.—(*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, pp. 197–199.)

3831. Principles of Fault-Tracing: Part III.—W. H. Cazaly. (*Wireless World*, Aug. 1940, Vol. 46, No. 10, pp. 370–373.) For previous parts *see* 3398 of September.

3832. On learning Morse: a Psychological Process in Two Distinct Stages.—R. Raven-Hart. (*Wireless World*, Aug. 1940, Vol. 46, No. 10, pp. 374–375.)

AERIALS AND AERIAL SYSTEMS

3833. Research on Wave Guides and Electromagnetic Horns: Report IV—Electromagnetic Waves radiated from the Open End of Wave Guides of Concentric Circular Section [Directional Characteristics of Radiated Waves due to $H_{0,1}$ and $E_{0,1}$ Waves].—S. Sonada. (*Electrotech. Journ.*, Tokyo, June 1940, Vol. 4, No. 6, pp. 126–129.) For previous parts *see* Morimoto, 3400 of September.

3834. Propagation of Electromagnetic Waves inside a Cylindrical Metal Tube and along Other Types of Guides.—H. C. Pen [Hsu]. (*See* 3718.)

3835. **Lines with Non-Uniformly Distributed Parameters.**—A. R. Volpert. (*Elektrosvyaz*, No. 2, 1940, pp. 40–65: Russian only.)

A mathematical discussion is presented on the properties of transmission lines whose parameters are continuous functions of the distance x from the sending end of the line, resulting in the characteristic impedance also depending on x. Differential equations (9) for the voltage and current in the line are derived, and also an equation (14) showing in a general form the variation of the characteristic impedance w_x. Solutions (26) of equations (9) are then found determining the voltage and current at any section of the line, for any load and any variation of w_x. Conditions of resonance (41–44) are established under which the input impedance (40) is 0 or ∞.

Formulae (52) and (54) are derived determining respectively the load necessary for ensuring the absence of reflected waves and the corresponding input impedance. It is shown that under these conditions the line acts as an impedance transformer having a ratio approximately equal to that of the characteristic impedances at the sending and distant ends of the line. It is pointed out that this property is independent of the resonance phenomena, in which respect the line compares favourably with the usual h.f. matching transformers (reactive elements, uniform lines). In view of the wide applications of matching transformers in radio technique, the operation of the line on a frequency band as a matching transformer between an aerial and a feeder is discussed in detail, and it is shown that the line is quite suitable for this purpose.

Throughout the discussion a number of particular cases of practical interest are considered separately. In conclusion, various methods of constructing such lines are examined (two divergent conductors; two parallel conductors each consisting of two divergent wires, Fig. 18; two parallel "ribbon" conductors of varying area, Fig. 19; etc.)

3836. **An Ultra-High-Frequency Antenna of Simple Construction** [Type MI-7823 at WCAU, Philadelphia, and Improved & Simplified Type MI-7823A: Vertical Quarter-Wave Radiator, above Four Horizontal "Ground Rods" on Outer Conductor of Concentric Feeder: with or without Reflector: Advantages].—G. H. Brown & J. Epstein. (*Communications*, July 1940, Vol. 20, No. 7, pp. 3–5.)

3837. **Antennas and Transmission Lines at the Empire State Television Station**: I [Preliminary Considerations—Choice of Polarisation, Transmission Line Principles, Matching].—N. E. Lindenblad. (*Communications*, May 1940, Vol. 20, No. 5, pp. 13–14 and 16..22.) First of three instalments: for a previous paper *see* 2759 of 1939.

3838. **Combined Television and All-Wave Sound Aerial** [Dipole, connected to Balanced Transmission Line for Ultra-High Frequencies, acts as Capacity Aerial for Lower Frequencies].—R.C.A. (*E. & Television & Short-Wave World*, July 1940, Vol. 13, No. 149, pp. 328 and 330.)

3839. **Horizontally Polarised Waves and Wide-Band** [Ultra-Short-Wave] **Loop Antennas.**—R.C.A. Laboratories. (*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, pp. 167 and 170.) Operating on the general principles of the Beverage aerial.

3840. **Dipoles and Reflectors** [for Ultra-Short Waves]: **a Short Review.**—S. Goldman. (*Electronics*, May 1940, Vol. 13, No. 5, pp. 20–22.)

3841. **A Note on Laguerre Polynomials.**—W. T. Howell. (*Phil. Mag.*, Sept. 1939, Vol. 28, No. 188, pp. 287–288.) For previous work *see* 2149 & 4382 of 1937.

3842. **Correction to Equation in "A General Radiation Formula."**—Schelkunoff. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 277.) *See* 108 of January.

3843. **On the Radiation from Conductors carrying Travelling Current and Voltage Waves.**—S. I. Nadenenko. (*Elektrosvyaz*, No. 2, 1940, pp. 66–70: Russian only.)

An aerial consisting of a single conductor of finite length, carrying a travelling current wave, is considered, and the effect of the attenuation caused by radiation losses is investigated. Formulae are derived determining the attenuation (20), radiation resistance (21), polar diagram (22), and efficiency (13). Curves are plotted showing the effect of the aerial length and characteristic impedance (300, 700, & 1000 ohms) on the radiation resistance (Fig. 2), directivity coefficient (Fig. 3), and efficiency (Fig. 4). A brief discussion of these curves is given and the advantages of low-impedance aerials are emphasised.

3844. **Surface of Captation of a Half-Wave Dipole** [equals Area of Circle with Radius 0.68λ, for Parallel, Tuned Dipoles at Sender & Receiver].—Y. Rocard. (*Sci. Abstracts*, Sec. B, 25th June 1940, Vol. 43, No. 510, p. 292.)

"If a tuned receiving dipole takes from the wave front a quantity W' of energy while the sender emits a total W of energy, W' may be considered as the fraction of W which passes through an area S (surface of captation) perpendicular to the direction of propagation and situated at the receiving dipole." For Rudenberg's "absorption surfaces" *see* Fränz, 2249 of June.

3845. **The Forced Oscillations of a Spherical Oscillator in a Circular** [Magnetic] **Flux.**—A. G. Arenberg. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 2, Vol. 26, 1940, pp. 147–150: in French.)

Further development of the work dealt with in 3405 of September, where "electric" excitation was considered. A comparison of the results then obtained with the present results for "magnetic" excitation shows that the expression now found for the moment of current Il differs from that for "electric" excitation only by the substitution of H_m for E_m: consequently when these values are equal the values P_{Σ} corresponding to the two methods of excitation are also equal (it is pointed out that the values of P_Σ cannot be compared by a comparison of the values of R_Σ, because in the "electric" case R_Σ was referred to the current intensity on the equator, in the "magnetic" case to the whole current traversing the sphere).

The values of P_Σ and R_Σ now found (eqn. 9) are maximum for $\lambda_r = 4.85a$. Here again (*cf.* 1857 of May) "this resonance value of λ_r does not coincide with that obtained by J. J. Thomson ["Recent Researches in Electricity and Magnetism"] for the case of free oscillations of the sphere. It is sufficient, in order to obtain this value for λ_0, to equate to zero, for $n = 1$ and $r = 0$, the expression (3) giving H_0. The equation $\xi'_n(ka)$, defining λ_0, is thus obtained."

3846. CURRENT DISTRIBUTION AND RADIATION PROPERTIES OF A SHUNT-EXCITED ANTENNA [Theoretical Examination of Assumption of Radiation Properties nearly the Same as Those of Insulated-Base Aerial].—P. Baudoux. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 271–275.)

"In most cases, the radiation resistance appears to be very different from that of the corresponding insulated-base antenna."

3847. THE INSULATION OF VERTICAL-MAST RADIATORS.—G. A. Savitski. (*Elektrosvyaz*, No. 2, 1940, pp. 76–83: Russian only.)

The requirements imposed on base and guy insulators for vertical-mast radiators are enumerated, and the mechanical properties of various insulating materials are shown in a table. Mechanical tests of these materials are discussed and different shapes of individual insulators are considered. This is followed by a survey, with numerous illustrations, of various methods of construction of the base and guy insulators, including some of the types developed in the U.S.S.R.; the relative advantages and disadvantages of these are pointed out. Practical suggestions are made.

3848. THE FIXED "ROTARY" BEAM ANTENNA: VARIABLE DIRECTIVITY WITH FIXED ANTENNAS.—A. H. Lynch. (*QST*, Aug. 1940, Vol. 24, No. 8, pp. 28–31.)

VALVES AND THERMIONICS

3849. ON THE THEORY OF TRANSIT-TIME [Retarding-Field & Magnetron] OSCILLATIONS, *and* THE ULTRA-SHORT-WAVE GENERATOR WITH PHASE-FOCUSING (KLYSTRON).—Lüdi. (*See* 3776 & 3777.)

3850. SIMPLE CALCULATIONS OF KLYSTRON EFFICIENCY.—E. U. Condon. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 204: short summary only.)

3851. ULTRA-HIGH-FREQUENCY POWER [Self-Excited Oscillator delivering 1 kW Average Power to Resistance Load at 600 Mc/s, using A.C. Anode Voltage].—D. H. Sloan & L. C. Marshall. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 193: summary only.) From the University of California. "A more powerful tube is being constructed to operate at 1000 Mc/s." No further information is given.

3852. AN ULTRA-HIGH-FREQUENCY PUSH-PULL PENTODE WITH 30 WATTS OPERATING ANODE DISSIPATION, TYPE 240 HH.—Western Electric. (Used in the 150 Mc/s amplifier dealt with in 3801, above.)

3853. SOME TYPICAL PHENOMENA RELATING TO ULTRA-SHORT-WAVE PENTODE [PB 3/800] AMPLIFIER CIRCUITS.—Posthumus & Gehrels. (*See* 3780.)

3854. PROGRESS IN THE DESIGN OF AUGETRONS FOR USE AT [Ultra-] HIGH FREQUENCIES.—Vacuum Science Products. (*E. & Television & Short-Wave World*, June 1940, Vol. 13, No. 148, pp. 273–274.) For earlier work *see* 2256 of June.

3855. HUM-NEUTRALISING CIRCUIT FOR USE WITH THE AUGETRON [used as a Voltage Amplifier: Economical Circuit for balancing-out Ripple on H.T. Supply].—Vacuum Science Products. (*E. & Television & Short-Wave World*, July 1940, Vol. 13, No. 149, p. 326.) For this special valve *see* 3854, above.

3856. A SECONDARY-EMISSION AMPLIFIER VALVE WITH SCREEN-GRID CHARACTERISTICS [obtained by Electron-Optical Compensation, using Anode Current to generate a Magnetic Field].—(*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, p. 148.)

3857. A METHOD FOR DETERMINING THE CHARGING POTENTIAL OF DIELECTRICS AND THE LOWER LIMIT OF SECONDARY ELECTRON EMISSION FROM A MONOCRYSTAL OF NaCl.—Kirvalidze. (*See* 3963.)

3858. DEPENDENCE OF SECONDARY EMISSION ON PRIMARY CURRENT [Influence of Internal Resistance on Secondary Emission: Latter should depend also on Primary Electron Current: Preliminary Experimental Confirmation].—N. Morgulis. (*Sci. Abstracts*, Sec. A, 25th July 1940, Vol. 43, No. 511, pp. 577–578.) For previous work *see* 1925 of 1939 and 1504 of April.

3859. NEUTRALISATION AND IONISATION OF Cs AND K ON THORIATED TUNGSTEN SURFACES [Experimental Investigation].—N. Morgulis & M. Bernadiner. (*Sci. Abstracts*, Sec. A, 25th July 1940, Vol. 43, No. 511, p. 586.) *See* also 3036 of August: for similar work on sodium atoms *see* 2802 of 1939.

3860. SURFACE STRUCTURE OF THORIATED TUNGSTEN EXAMINED BY THE IONIC MICROSCOPE.—N. Morgulis. (*Sci. Abstracts*, Sec. A, 25th July 1940, Vol. 43, No. 511, p. 586.)

3861. FLUCTUATIONS IN SPACE-CHARGE-LIMITED CURRENTS AT MODERATELY HIGH FREQUENCIES: PART II (CONTD.)—DIODES AND NEGATIVE-GRID TRIODES [Experiments on about 1 Mc/s (to avoid Transit-Time Effects and Flicker Effect): Methods of Shot-Effect Measurement: Estimation of Cathode Temperatures (Optical Pyrometer discarded for Sleeve-Type Cathodes: Computation from Heater-Power Formula—Widell):

Estimation of σ (Transconductance/Conductance of "Equivalent Diode"): Comparison with Theory].—D. O. North. (*R.C.A. Review*, July 1940, Vol. 5, No. 1, pp. 106–124: to be contd.) Continued from 3420 of September.

3862. The Fourth-Power Law for Determination of Emissivities of Sleeve-Type Cathodes, and a Working Formula.—E. G. Widell. (Used for the computation of cathode temperatures in the work dealt with in 3861, above.)

3863. Zone Model of Oxide Cathodes [Wilson's "Impurity Semiconductor" Model, modified by Allowance for Two-Dimensional Metal Layer on Surface, gives Richardson Equation and Coinciding Thermionic & Photoelectric Work Functions: etc.].—Y. Uehara & M. Takahasi. (*Sci. Abstracts*, Sec. A, 25th July 1940, Vol. 43, No. 511, p. 586.)

3864. Optimum Emission from Solid Solution of BaO and SrO at a Particular Composition, and Its Explanation.—Uehara & Takahasi. (In paper dealt with in 3863, above.)

3865. A Recent Improvement in Filamentary Cathodes [Cathodically Electrolysed Thoriated Tungsten or Molybdenum Filaments and Their Advantages for Ultra-High Frequencies and for High Voltages].—R.C.A. Laboratories. (*E. & Television & Short-Wave World*, June 1940, Vol. 13, No. 148, pp. 244 and 249.)

3866. Applications of X-Ray Technique to Industrial Laboratory Problems [Valve-Cathode Coatings, Fluorescent Screens, etc.].—H. P. Rooksby. (*G.E.C. Journ.*, Aug. 1940, Vol. 11, No. 2, pp. 83–95.)

3867. Thermionic Measurement of e/m [Simple Method, from Current to Cylindrical Anode].—F. M. Gager. (*Sci. Abstracts*, Sec. A, 25th July 1940, Vol. 43, No. 511, p. 576.)

3868. Observations on Field Currents from Tantalum [Study of Fluorescent Areas produced on Walls of Flask by Electrons from Tantalum Point at Centre].—G. M. Fleming & D. M. Holtoner. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 189: summary only.)

3869. Electron Emission into Dielectric Liquids [Experiments to examine the Baker & Boltz Theory of Thermionic Production of Conduction Currents: Suggestion of Combined Thermionic & Field Emission].—W. R. LePage & L. A. DuBridge. (*Phys. Review*, 1st July 1940, Vol. 58, No. 1, pp. 61–66.) *See* 1820 of 1937.

3870. Neutralising Screened-Grid Valves [to overcome Tendency to Instability in Specially Good Circuits].—Stokes. (*See* 3818.)

3871. On Choosing the Optimum Operating Conditions for the Final Stage of a L.F. Amplifier, taking into Account the Non-Linearity of Valve Characteristics.—Krize. (*See* 3762.)

3872. Harmonic Analysis by the Method of Central Differences [with Particular Reference to Distortion in Thermionic Valves, but applicable to Most Non-Linearity Problems].—D. C. Espley. (*Phil. Mag.*, Sept. 1939, Vol. 28, No. 188, pp. 338–352.)

Equation of load line: coefficients of frequency terms: numerical example: special considerations: direct measurement of first-order differences (cathode-ray oscillograph equipment for dynamic-characteristic measurement).

3873. Measuring Valve Capacities with a Signal Generator.—Hygrade Sylvania. (*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, p. 176.)

3874. Oscillographic Method of measuring Positive-Grid Characteristics [by Condenser-Discharge Impulses controlled by Thyratrons: with Cathode-Ray Oscillograph].—O. W. Livingston. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 267–268.) With "advantages in accuracy and economy" over previous methods.

3875. Measurement of Transmitting Valve Characteristics above the Dissipation Limit [Simple Method using Motor-Driven Switch and D.C. Meters].—G. Stolzer & J. A. Sargrove. (*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, pp. 153–156.) A Tungsram paper.

3876. Air Cooling applied to External-Anode Tubes [Principles of Low-Pressure Forced-Air Cooling: Mechanical Design: Electrical Characteristics: Operation].—E. M. Ostlund. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 36–39.)

3877. The Influence of "Cold Ends" on Performance of Vacuum-Tube Air Coolers [Mathematical Investigation and Application to Valve with External Copper Anode: Permissible Anode Dissipation as Function of Air Velocity: etc.]—I. E. Mouromtseff. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 204: summary only.)

3878. Suggestions for Radio Standardisation: a War Economy Measure proposed by the British Institution of Radio Engineers.—Sargrove. (*E. & Television & Short-Wave World*, July 1940, Vol. 13, No. 149, pp. 314 and 315.) *See* also 3435 of September.

3879. Tube Registry [Valve Types registered by R.M.A. Data Bureau during March 1940].—(*Electronics*, May 1940, Vol. 13, No. 5, pp. 56. . 65.) A monthly feature.

3880. Locktal-Tube Design and Manufacture.—R. M. Wise. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 286: summary only.) *See* also 3159 of 1939 and 2273 of June.

3881. The Principle [and Construction] of the New Beam Mixer Valve Type 6K8G [American "Triode Hexode," but in Circuit & Operation a Beam Pentagrid].—(*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, p. 164.)

3882. Materials for Vacuum Tube Manufacture.—A. J. Monack: R.C.A. (*Indust. & Eng. Chemistry*, Industrial Edition, 1st Aug. 1940, Vol. 32, No. 8, pp. 1028–1033.)

3883. The Micro-Analysis of Gases by Physical Methods.—C. E. Ransley. (*G.E.C. Journ.*, Aug. 1940, Vol. 11, No. 2, pp. 135–141.) Of interest, among other applications, in valve manufacture.

DIRECTIONAL WIRELESS

3884. Radio Direction-Finding for Meteorological Balloons at 1.67 Metres.—L. C. Yuan & S. S. Mackeown. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 286: summary only.) *See* also 3041 of August.

3885. Some Theoretical Considerations on the Philips' Ultra-Short Wave Radio-Beacon [Development on Principles of Long-Wave Beacon: Direction of Course Line: Width of Course Sector: Field Strength in Direction of Course].—P. Zijlstra. (*Philips Transmitting News*, Dec. 1939, Vol. 6, No. 3/4, pp. 59–62: to be contd.) For earlier work *see* 2363 of 1938.

3886. Distance Measurements by Wireless [Description of Systems using Cathode-Ray Oscillographs as Indicators].—(*Sci. Abstracts*, Sec. B, 25th July 1940, Vol. 43, No. 511, p. 310.)

3887. Radio Compass giving Intersecting Traces, on Screen of Dual-Ray Cathode-Ray Tube, from Two Separate Stations [Map projected on to Same Screen: Gyrostatic Control of Indicating Mechanism].—J. B. Dearing: R.C.A. (*Science*, 2nd Aug. 1940, Vol. 92, Supp. p. 8: *Sci. News Letter*, 3rd Aug. 1940, Vol. 38, No. 5, p. 73.)

3888. Panoramic Reception [for Navigation, etc: Latest Development, with Electronic Sweep Circuit: the Dual-Frequency Radio Range Beacon demonstrated to C.A.A.].—M. Wallace. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 14–15 and 84..88.) *See* also 3385 of September.

3889. A Proposal for Reduction of Polarisation Errors in Loop Direction-Finders [avoiding Defects of Adcock System: Unwanted Component from Multi-Turn Loop neutralised by Additional Horizontal Pick-Up from Auxiliary (Dipole) Aerial rotating with Loop].—F. E. Terman & J. M. Pettit. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 285: summary only.)

ACOUSTICS AND AUDIO-FREQUENCIES

3890. Multi-Stage Standing-Wave Circuits [with Application to Frequency Stabilisation and Acoustics].—Okabe. (*See* 3756.)

3891. Mutual Acoustic Impedance in Multiple-Speaker Systems [and Its Effect on Efficiency & Directional Characteristics: "Space Phasing"].—H. S. Knowles. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 283: summary only.)

3892. Stereophonic Recordings of Enhanced Music [Note on Carnegie Hall Demonstrations].—Bell Laboratories. (*Nature*, 3rd Aug. 1940, Vol. 146, p. 174.) *See* 3056 of August, and *Electronics*, May 1940, pp. 30–31.

3893. Design of a 27-Inch Loudspeaker [with Voice-Coil Travel up to ¾ Inch: Paper-Thin Former of "Acim" Metal: Polyfibrous Cone Material].—R. T. Bozak. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 22–24.) A group of these handled 2000 watts of a.f. power at the Lagoon of Nations Display.

3894. New Type of "Accordion Edge" Loudspeaker Cone increases Lower Reproduction Range by at least One Octave.—R.C.A. (*Electronics*, June 1940, Vol. 13, No. 6, p. 106: paragraph & photograph only.)

3895. The C25 Acoustical Amplifier: a Compact Unit suitable for Mobile [Public Address] Equipment.—Acoustical Mfg. Company. (*Wireless World*, Aug. 1940, Vol. 46, No. 10, p. 356.) For a.c. mains or 12-volt car battery.

3896. Bass Compensation by Screen-Grid Injection ["Syncrotronic" System].—Barcus. (*See* 3819.)

3897. Further Applications of Space-Charge Coupling [particularly to Condenser-Microphone Amplification].—Sargrove. (*See* 3760.)

3898. A Direct-Current and Audio-Frequency Amplifier [Stable in Operation, capable of Linear Amplification of Voltages from a Few Microvolts to 30 Millivolts: for Stress or Illumination Measurements, Nerve-Action Currents, etc: Signal Voltage controls Balance of Bridge Modulator Circuit fed by Carrier Voltage].—L. J. Black & H. J. Scott. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 269–271.)

3899. A New Method of Logarithmic Rectification.—Hayasi & Akasi. (*See* 3759.)

3900. Volume Range of Sound-on-Film Recording [including Methods of Increasing It (Bell Laboratories' Experiments with Compression-Control Current recorded on Separate Track and used for Expansion Control): etc.].—R. H. Cricks. (*E. & Television & Short-Wave World*, June 1940, Vol. 13, No. 148, pp. 245–249.)

3901. Frequency Characteristics of Film-Recorded Sound [and the Overcoming of Defects & Limitations due to Photographic & Mechanical Difficulties].—R. H. Cricks. (*E. & Television & Short-Wave World*, July 1940, Vol. 13, No. 149, pp. 293–296.) Concluded in the August issue.

3902. Sound on Film: Photographic Methods of Recording [and the Reduction of Background Noise].—R. F. E. Miller. (*Wireless World*, Sept. 1940, Vol. 46, No. 11, pp. 386–388.)

3903. Photoelectric Tape Recording [Mechanical Engraving for Photoelectric Reproduction].—(*Electronics*, May 1940, Vol. 13, No. 5, pp. 16–18.)

3904. Further Notes on the Construction and Operation of the Steel-Wire Recording Apparatus.—R. L. Mansi. (*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, pp. 227..233.) Concluded from 2289 of June. For criticisms *see* pp. 237, 238.

3905. Barrier-Layer Photocells for Sub-Standard Talkies.—(*See* 3971.)

3906. Photoelectric Gramophone Pick-Up.—Philco. (*Communications*, July 1940, Vol. 20, No. 7, pp. 13–14.) *See* also 3449 of September.

3907. Titanium Compounds as Fillers in Resin Moulding Compositions: Reduced Surface Noise and Increased Life of Gramophone Records.—R.C.A. (*Wireless World*, Aug. 1940, Vol. 46, No. 10, p. 364: paragraph only.)

3908. The Resonoscope [for the Accurate Tuning of Musical Instruments].—S. K. Wolf & L. B. Holmes. (*Electronics*, June 1940, Vol. 13, No. 6, p. 92: summary only.)

3909. Electronic Music [Discussion of Various Types of Pick-Up Devices, for Pianos, Violins, etc.].—N. I. Daniel. (*Communications*, July 1940, Vol. 20, No. 7, pp. 26–30.)

3910. On New Results in Research on Violins.—H. Backhaus & G. Weymann. (*Journ. Acous. Soc. Am.*, April 1940, Vol. 11, No. 4, pp. 490–492.) Long summary of the German paper dealt with in 651 of February.

3911. An "Acoustic Tone" from Bells [may result from Simultaneous Sounding of Second & Third Partials: also on Piano, etc.].—J. Arts. (*Journ. Acous. Soc. Am.*, April 1940, Vol. 11, No. 4, p. 485).

3912. A Speaking-Aid [for Those who are Dumb by Injury of Vocal Chords: supplying Sound Vibrations in Throat, which can be Modulated into Speech].—G. Wright. (*Electronics*, June 1940, Vol. 13, No. 6, p. 44: photograph & caption.)

3913. Amplifying Power of Ear Trumpets.—Y. Rocard. (*Sci. Abstracts*, Sec. A, 25th July 1940, Vol. 43, No. 511, p. 563.)

3914. Receiver [Telephone or Deaf-Aid] Testing with an "Artificial Ear."—S. Ballantine. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 34–35 and 108..112.)

3915. Measurements of the Directional Properties of the Ear carried out with a Dummy.—L. D. Rosenberg & A. B. Slavinsky. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 6, Vol. 26, 1940, pp. 578–580: in English.)

Certain unexpected results were obtained: one of these "throws some light upon the mechanism of location of sound sources in the normal plane, which has not been explained successfully as yet."

3916. Effect of Noises of Warfare on the Ear.—T. S. Littler. (*Nature*, 17th Aug. 1940, Vol. 146, pp. 217–219.)

3917. Reversed Speech.—E. W. Kellogg. (*R.C.A. Review*, July 1940, Vol. 5, No. 1, pp. 101–105.) Already dealt with in 3193 of 1939.

3918. The Physiology of the Ear in Relation to Talking Pictures.—A. F. Rawdon-Smith. (*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, pp. 190 and 191: summary only.)

3919. On the Theory of Acoustic Feedback in Sound-Reinforcing Systems.—J [G.] M. Suharevsky. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 5, Vol. 26, 1940, pp. 430–435: in English.)

For previous work on sound-reinforcing systems *see* 3458 of September. The excitation of free oscillations, through acoustic feedback, "is the most undesirable feature of such systems." The problem has been discussed by Bovsheverov (54 of 1937 and back reference), Gorelik (540 of February), and its more detailed analysis was given by Bürck (3997 of 1938 and back reference) "who, however, has not considered some important cases," and some of whose equations "are not quite correct." The present paper considers the case of systems out of doors, including that formed by a microphone with many loudspeakers in concentric rings around it: the changes in the equations, to make them apply to the case of a closed room (when the squares of the pressures, instead of the pressures themselves, have to be summed up: but *see* footnote on p. 434), are given in eqns. 13–15. Eqn. 18 gives the ratio between the times of regenerative and natural reverberation. "In the papers next to be published [*see* 3920, below] I shall set forth the results that my experimental investigation of acoustic feedback in a closed room has yielded, and the question of the maximum possible reinforcing of sound (acoustic feedback being the limiting factor) will also be discussed there."

3920. On Experimental Investigation of Acoustic Feedback in a Closed Room.—G. M. Suharevsky. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 7, Vol. 26, 1940, pp. 638–643: in English.)

See 3919, above. Among the results obtained, the critical value (for noticeable distortions and "ringing") of T_r/T was found, in the reinforcing of speech, to be 4.5 for a male voice and 3.0 for a female, when the frequency of free vibrations (due to acoustic feedback) was 1200 c/s: the corresponding values for a free-vibration frequency of 600 c/s were 2.1 and 1.7. The use of the formulae and experimental data for the design of systems, and in particular for the determination of the maximum reinforcement possible, will be dealt with in papers already in the press.

3921. The Use of "Acoustivanes" in C.B.S. New Studios.—(*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, p. 165: paragraph only.)

3922. Satellite-Studio Equipment [for Intermittent Use for Broadcasts from Adjacent Town].—G. S. Feikert. (*Communications*, May 1940, Vol. 20, No. 5, pp. 10–11 and 23.)

3923. Froth Glass [containing Closed Pores of Definite Dimensions, separated by Very Thin Walls: Production in Russia in form of Bricks: Low Heat & Sound Conductivity].—I. I. Kitaigorodski. (*Comptes Rendus* (*Doklady*) *de l'Ac. des Sci. de l'URSS*, No. 7, Vol. 26, 1940, pp. 644–646: in English.)

3924. Calibration Circuit for Audio Oscillators [Drift of Beat-Frequency Oscillators accurately checked by Cathode-Ray Indicator, using A.C. Components of Rectified & Smoothed Mains Voltage].—T. J. Rehfisch & H. T. Bissmire. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 48..52.) From the Murphy Radio Laboratories.

3925. A Resistance-Capacitance Audio-Frequency Oscillator [One-Valve Circuit: Harmonic Contents less than ¼%: Frequency Stability better than 1 Part of 10 000 for 10% Supply-Voltage Variation].—G. A. Brettell. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 282: summary only.)

3926. A Multi-Frequency Oscillator for Audio Testing [in Investigations on Tonal Memory: 15 Separate Oscillators, beating with a Master Oscillator in Sequence determined by Perforations in Tape].—J. Quinn. (*Electronics*, May 1940, Vol. 13, No. 5, pp. 23–25.)

3927. Measurements of Noise and Vibration [including New Developments in Apparatus].—H. H. Scott. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 284–285: summary only.)

3928. Distortion Measurements by Fundamental-Suppression Methods.—Hewlett & Packard. (*See* 3988.)

3929. The Design and Test of Equipment by the Intermodulation Method [Comparison between Harmonic Method & Intermodulation Method: etc.].—J. K. Hilliard. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 283: summary only.)

3930. Sound Tests of Telephone Ringers and Dials [Use of Irregularly Shaped Testing Box (No Parallel Walls) with Set of Rotating Vanes of Irregular Shape between Specimen & Microphone].—N. R. Stryker. (*Bell Lab. Record*, July 1940, Vol. 18, No. 11, pp. 343–344.)

The many reflections thus obtained reduce the effects of variations in the sound radiated from moment to moment, and tend to equalise the effects of the different frequencies obtained with the various ringers.

3931. "Cumulative Index, Volumes 1 to 10 of the Journal of the Acoustical Society of America" [dealing also with Abstracts of Contemporary Literature: Book Review].—(*Communications*, June 1940, Vol. 20, No. 6, p. 25.)

3932. Velocity and Absorption of Ultra-Acoustic Waves in Some Binary Liquid Mixtures [Sharp Maximum of Velocity at 30% Concentration (due to Decrease of Adiabatic Contraction): etc.].—Mikhailov. (*Comptes Rendus* (*Doklady*) *de l'Ac. des Sci. de l'URSS*, No. 2, Vol. 26, 1940, pp. 145–146: in English.)

The method used depended on the detection of the onset of stationary waves by the optical diffraction effect—*see* Wyss, 3029 of 1937.

3933. Ultrasonic Absorption in Liquids, *and* Absorption of Supersonic Waves in Gases.—Gregg: Zartman & Smith. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 208: pp. 208–209: summaries only.)

3934. Supersonic Velocity in Gases and Vapours: Part IX—Specific Heats and Dispersion of Supersonic Velocity in Organic Vapours.—S. K. K. Jatkar. (*Indian Journ. of Phys.*, Dec. 1939, Vol. 13, Part 6, pp. 445–449.)

3935. The Absorption of Sound in Carbon Dioxide [Frequency Range 22–112 kc/s].—R. W. Leonard. (*Phys. Review*, 1st Feb. 1940, Ser. 2, Vol. 57, No. 3, p. 253: abstract only.)

PHOTOTELEGRAPHY AND TELEVISION

3936. Demonstrating Broadcast Facsimile [Radio Newspaper] at the New York World's Fair.—A. J. Baracket. (*R.C.A. Review*, July 1940, Vol. 5, No. 1, pp. 3–7.)

3937. Photo Transmission by Frequency Modulation [Recent Demonstration: Relaying over Two Paths totalling 87 Miles].—(*Communications*, July 1940, Vol. 20, No. 7, p. 14.)

3938. A 500-Megacycle [Frequency-Modulated] Radio-Relay Distribution System for Television.—Kroger, Trevor, & Smith. (*See* 4080.)

3939. Portable Television Broadcasting [from Station W6XAO: Technique of Determination of Propagation Conditions on 324 Mc/s: "Pitchfork" Aerial: etc.].—H. R. Lubcke. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 283–284: summary only.) For more about this station *see* 1944 of May.

3940. Interference between Television (and Sound) Signals from Philco (Philadelphia) and C.B.S. (New York) Stations, separated by 90 Miles.—(*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, p. 207: paragraph only.)

3941. Antennas and Transmission Lines at the Empire State Television Station: I.—Lindenblad. (*See* 3837.)

3942. A Determination of the Optimum Number of Lines in a Television System [Criticism of Previous Hypotheses: Reproduction of an Abrupt Change in Brightness as a Measure of Resolution: Vertical & Horizontal Resolution: Choice of Frame Frequency: Choice of Number of Lines: etc.].—R. D. Kell, A. V. Bedford, & G. L. Fredendall. (*R.C.A. Review*, July 1940, Vol. 5, No. 1, pp. 8–30.)

A number of lines between 441 and 507 (at 30 frames per second) is arrived at as providing nearly optimum picture quality for present receivers and future improved types, for the maximum v.f. signal of 4.5 Mc/s which is available with the vestigial-sideband method of transmission (*cf.* 3477 of September) within the U.S.A. channel of 6 Mc/s, including sound.

3943. Reduction of the Frequency Band in Television Transmission [Discussion of Known Methods: Writer's Tests on Resolving Power of the Eye: Light-Retentive Screens (and a Suggested Quenching Ray preceding the Exciting Ray): etc.].—R. W. Urie. (*E. & Television & Short-Wave World*, July 1940, Vol. 13, No. 149, pp. 303–306.)

3944. Television in Natural Colour [System involving No Changes in Transmitting or Receiving Station except to Photoelectric Pick-Up at Transmitter and Cathode-Ray Tube at Receiver].—R. Lorenzen. (*Communications*, June 1940, Vol. 20, No. 6, pp. 8 and 27, 28.) A 1940 patent.

3945. Fundamentals of Television Engineering: Part IX [Foreign Developments (England, Italy, France, Germany)]: Part X [Conclusion: Promising Developments, including Small Projection Tubes, & German Trials for Medium-Size Images for Home Receivers: Zinc-Blende & "Suspensoid" (Colloidal Graphite) Light Relays: etc.].—F. A. Everest. (*Communications*, June & July 1940, Vol. 20, Nos. 6 & 7, pp. 12–16 and 27: pp. 7–8 and 18, 19.) For previous parts *see* 2657 of July.

3946. Automatic Background Control of Television Pictures.—General Electric. (*E. & Television & Short-Wave World*, July 1940, Vol. 13, No. 149, pp. 324 and 326.)

3947. Television and the F.C.C. [the Question of Standards].—(*Electronics*, May 1940, Vol. 13, No. 5, pp. 11–13 and 79..83.)

3948. "Television—the Electronics of Image Transmission" [Book Reviews].—Zworykin & Morton. (*Science*, 2nd Aug. 1940, Vol. 92, p. 108: *Wireless Engineer*, Sept. 1940, Vol. 17, No. 204, pp. 397–398.)

3949. RCA Portable Television Pick-Up Equipment ["Suitcase" Construction].—G. L. Beers. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 281–282: summary only.)

3950. A New and Original Television Pick-Up Tube [based on Properties of Electrostatic Field around Thin Wire].—H. Browde [G. V. Braude]. (*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, pp. 196 and 233.) Summary of Braude's paper dealt with in 592 of 1938.

3951. Television Receiver Characteristics.—C. F. Wolcott. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 286: summary only.)

3952. Television Receivers using Electrostatic Deflection [Reasons for DuMont Preference for Electrostatic over Magnetic Scanning: Typical Receiver for 14 or 20 Inch Tubes (with Accelerating Ring near Screen)].—T. T. Goldsmith, Jr. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 16–19 and 89.)

3953. A Reflex Television Amplifier: a New Amplifier using Balanced Bridge Circuits.—General Electric. (*E. & Television & Short-Wave World*, July 1940, Vol. 13, No. 149, pp. 311 and 336, ii.)

3954. Voltage Dividers for Extended Frequency Ranges [in Television, etc.].—F. A. Everest. (*Communications*, May 1940, Vol. 20, pp. 8–9 and 22, 23.)

3955. Halation on Kinescope Screens [and Methods of Reduction by Films between Phosphor & Glass Envelope].—R. F. Baker. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 208: summary only.)

3956. Production Colour-Analysis of Kinescope Screens [Apparatus for Analysing the "Degree of Whiteness"], *and* Optimum Efficiency Conditions for White Luminescent Screens in Kinescopes.—T. B. Perkins: H. W. Leverenz. (*Journ. Opt. Soc. Am.*, July 1940, Vol. 30, No. 7, pp. 295–296: pp. 309–315.) Both from the R.C.A. Mfg. Company. The second paper contains spectral distribution curves of relative absorption and emission for various screens.

3957. Mixing and Limiting Circuits for Picture Signals and Blacking-Out Pulses.—R. C. A. Laboratories. (*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, pp. 225–226.)

3958. Separating Vision and Sound Signals [when using a Single Local Oscillator: Special Filter Circuits].—General Electric. (*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, pp. 184 and 185.)

3959. Square-Wave Harmonics [with Table of Relative Amplitudes of Harmonic Components (computed to 30th Harmonic) of Interest in Television].—D. L. Herr. (*Electronics*, May 1940, Vol. 13, No. 5, p. 34.)

3960. Television Pulse Generator [for Development & Testing of Synchronising Filter Circuits, Scanning Circuits, etc: giving B.B.C. Standard Wave Form and Other Outputs].—British Thomson-Houston. (*Journ. of Scient. Instr.*, Aug. 1940, Vol. 17, No. 8, p. 214.)

3961. A Precision Television Synchronising-Signal Generator [for R.M.A. Standard Signals: Narrowest Pulse from Frequency-Regulated Master Oscillator and Multivibrator: Other Pulses obtained by "Lap-Joining" to Trailing End of This: Blanking-Out of Undesired Pulses: etc.].—A. V. Bedford & J. P. Smith. (*R.C.A. Review*, July 1940, Vol. 5, No. 1, pp. 51–68.)

3962. A Picture-Signal Generator: II [Synchronising-Signal Generator, including Timer & Shaper Units]: III [Mixing & Line Amplifiers and Shading-Signal Generator].—Wilder & Brustman. (*Electronics*, May 1940, Vol. 13, No. 5, pp. 26–29: June, No. 6, pp. 30–33.) For I *see* 2667 of July.

3963. A Method for Determining the Charging Potential of Dielectrics and the Lower Limit of Secondary Electron Emission from a Monocrystal of NaCl.—I. D. Kirvalidze. (*Comptes Rendus (Doklady) de l'Ac. des Sci. de l'URSS*, No. 7, Vol. 26, 1940, pp. 635–637: in English.)

A determination of the threshold of secondary emission is possible by the "thermal" method (Vudynski, 4480 of 1938: *see* 211 of January and 2261 & 2262 of June for later work) only at temperatures at which the conductivity is such that the surface does not charge up: "no convenient method has been devised for the case of low or room temperatures." The writer's method depends on determining the sign of the charge on the dielectric, as the velocity of the incident electron beam is varied: the threshold of secondary emission is given by the electron velocity at which the crystal begins to be charged positively. The apparatus is described, and the results on a NaCl single crystal are given: secondary emission begins at electron velocities of about 11 volts.

3964. Photocell Multiplier Tubes [Cs-Cs$_2$O-Ag Vacuum Cell in Bulb with 6- or 11-Stage Electron Multiplier: Structure, Performance, & Applications (Useful whenever Low Light Level or Large Frequency Range is involved): Similar (except in Size) to Multiplier used in Farnsworth Image Dissector].—C. C. Larson & H. Salinger. (*Review Scient. Instr.*, July 1940, Vol. 11, No. 7, pp. 226–229.) *See* also below (Farnsworth).

3965. Electron-Multiplier Phototube [6-Stage & 11-Stage Sizes, Two Types in Each Size: Dark Noise equivalent to about 2×10^{-7} Lumen for Frequency Range of 10 kc/s].—Farnsworth. (*Electronics*, May 1940, Vol. 13, No. 5, pp. 54 and 56.) *Cf.* 3964, above.

3966. Experiences with Electron-Multiplier Photocells of Different Types, as regards Dark Current and Stability.—Harrison & Bentley. (In paper dealt with in 4156, below.)

3967. Photoelectric Cells sensitive to Long-Wave Radiation: the Bismuth-Sulphide Cell [with 80% of Its Activity in the Infra-Red: Max. Sensitivity at 70 000 A.U.].—C. G. Fink & J. S. Mackey. (*Electronics*, June 1940, Vol. 13, No. 6, p. 93: summary only.)

3968. "Photoelectric and Selenium Cells: Second Edition" [including Industrial Applications: Book Review].—T. J. Fielding. (*Wireless Engineer*, Sept. 1940, Vol. 17, No. 204, p. 398.)

3969. Photosensitivity of Cu$_2$O Electrodes [Experiments supporting Barrier-Layer Origin of Becquerel Effect].—E. Miseliuk. (*Sci. Abstracts*, Sec. A, 25th July 1940, Vol. 43, No. 511, p. 586.)

3970. The Manufacture of [Selenium] Barrier-Layer Photocells: a New British Industry.—Electro-Physical Laboratories. (*E. & Television & Short-Wave World*, July 1940, Vol. 13, No. 149, pp. 312–313.)

3971. Barrier-Layer Photocells for Sub-Standard Talkies [Specially Small Selenium Cells for Sound Reproduction: Types S5 & S5X].—Tungsram. (*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, p. 159.)

3972. R.C.A. Phototube Reference Chart.—R.C.A. (*Electronics*, June 1940, Vol. 13, No. 6, p. 73.)

MEASUREMENTS AND STANDARDS

3973. Field-Strength Measuring Equipment at 500 Megacycles [Signal Generator, 400–580 Mc/s, Output continuously variable from 0.1 Volt to below 1 Microvolt (Special Attenuator Design): Half-Wave Dipole: Peak-Signal & Noise Measurements].—R. W. George. (*R.C.A. Review*, July 1940, Vol. 5, No. 1, pp. 69–76.) For work on ignition-interference measurement *see* 2981 of August.

3974. Multi-Range Valve Voltmeter [for Frequencies 20 c/s to 50 Mc/s: Diode with Small Closely Spaced Electrodes, operated by Single Dry Battery: Probe H.F. Circuit on Flexible Cable].—Cambridge Instrument. (*Journ. of Scient. Instr.*, July 1940, Vol. 17, No. 7, p. 192.)

3975. Transmission-Line Method of Measuring the Dielectric Constant of Gases and Water Vapour at Ultra-High Frequencies [D.C. of Water Vapour practically Independent of Frequency up to at least 150 Mc/s].—J. P. Hagen, M. Distad, & F. C. Iseley. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 208: summary only.)

3976. On the Determination of the Dielectric Constants of Liquids at Radio Frequencies: Parts III & IV [Methyl Alcohol, Water, & Alcohol-Water Mixtures].—R. M. Davies & T. T. Jones. (*Phil. Mag.*, Sept. 1939, Vol. 28, No. 188, pp. 289–306 & 307–327.) For previous parts *see* 2747 of 1936.

3977. Ultra-High-Frequency Oscillator Frequency-Stability Considerations.—Seeley & Anderson. (*See* 3802.)

3978. Negative Feedback applied to Oscillators [for Frequency Stabilisation].—Sabaroff. (*See* 3766.)

3979. Signal Generator Type TF.517A [150–300 Mc/s: "Acorn" Triode in Hartley Circuit: Short-Circuited Transmission Line loaded with Capacity to provide Frequency Variation].—Marconi-Ekco. (*E. & Television & Short-Wave World*, June 1940, Vol. 13, No. 148, p. 254.)

3980. Wavemeter Type TF.643 [20–300 Mc/s].—Marconi-Ekco. (*E. & Television & Short-Wave World*, June 1940, Vol. 13, No. 148, p. 254.)

3981. Beat-Frequency Crystal Oscillator [Frequencies from 1 kc/s to 1 Mc/s from Two Short-Wave Crystals].—Koga & Yamamoto. (*See* 3791.)

3982. A Precision Crystal Frequency Standard using a 1000-kc/s Crystal for General Amateur Measurement.—G. M. Brown. (*QST*, Aug. 1940, Vol. 24, No. 8, pp. 13–16 and 76..80.)

3983. Straight-Line Calibration for Wavemeters and Oscillators [Improved Calibration by Use of Series Padding Condensers in conjunction with Parallel Trimmers].—W. A. Roberts. (*Wireless World*, Sept. 1940, Vol. 46, No. 11, pp. 408–409.)

3984. Mechanism of Operation of Multivibrator [Experimental Study and Theoretical Conclusions].—Hukata & Orihara. (*See* 3772.)

3985. Theory of a Single-Layer, Bifilar, Absolute Standard of Mutual Inductance [Equal-Diameter Wires, Equally Spaced, with Equal Cylindrical Radii, with Allowance for Case where These Equalities are Not Quite Attained].—C. Snow. (*Journ. of Res. of Nat. Bur. of Stds.*, June 1940, Vol. 24, No. 6, pp. 597–638.)

3986. A Circuit for the Rapid Measurement of the Power Factor of Condensers [adaptable also to Determination of Magnitude & Angle of Any Impedance: Ionisation quickly Detected: Transformer with Tapped Secondary, Variable Low-Power-Factor Condenser, & Rectifier-Type Microammeter with Shunts].—E. A. Walker. (*Review Scient. Instr.*, July 1940, Vol. 11, No. 7, pp. 210–211.)

3987. The Design and Test of Equipment by the Intermodulation Method [Comparison between Harmonic Method & Intermodulation Method: etc.].—J. K. Hilliard. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 283: summary only.)

3988. Distortion Measurements by Fundamental-Suppression Methods [Method using Filter for Suppression, and Cathode-Ray Oscilloscope: Method using Local Synchronised Oscillator & Resistance Bridge, with Meter of Total R.M.S. Type].—W. R. Hewlett & D. Packard. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 283: summary only.)

3989. Generation of Square-Wave Voltages at High Frequencies.—Fenn. (*See* 3793.)

3990. Measuring Valve Capacities with a Signal Generator.—Hygrade Sylvania. (*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, p. 176.)

3991. Measurement of Transmitting Valve Characteristics above the Dissipation Limit.—Stolzer & Sargrove. (*See* 3875.)

3992. Work's Method for Balancing the Kelvin Double Bridge [for measuring Low Resistances: Balance obtained by passing Adjustable Auxiliary Current through Standard].—G. R. Patterson. (*Review Scient. Instr.*, July 1940, Vol. 11, No. 7, pp. 217–219.)

3993. Apparatus for Determining the Number of Turns in Coils.—Metropolitan-Vickers. (*Journ. of Scient. Instr.*, July 1940, Vol. 17, No. 7, pp. 191–192.)

3994. The Lagometer [Instrument on Condenser-Charging Principle for Time Measurements, *e.g.* on Relays].—Bryan. (*Sci. Abstracts*, 25th July 1940, Vol. 43, No. 511, p. 310.)

3995. Corrections to "On the Direct and Semi-Direct Determination of the Critical Resistance of Moving-Coil Galvanometers."—Gerszsonowicz. (*Rev. Gén. de l'Élec.*, 25th May/1st June 1940, Vol. 47, No. 21/22, p. 372.) *See* 3139 of August.

3996. On the Geometry of Optical Indicators.—K. J. Dejuhasz. (*Journ. Franklin Inst.*, Jan. 1940, Vol. 229, No. 1, pp. 53–80.) For a German version *see* 1974 of May.

3997. A Simplified Multiple Scale for Measuring Instruments [and Radio Receivers, etc.]: the Rotoroid Rotating Scale.—(*Electronics*, June 1940, Vol. 13, No. 9, p. 99.)

3998. Precision Four-Dial Vernier Potentiometer [Fourth Dial extends Subdivision to One Part in a Million].—Tinsley. (*Journ. of Scient. Instr.*, Aug. 1940, Vol. 17, No. 8, p. 213.)

3999. The Welding of Thermocouple Junctions.—V. M. Hickson. (*Journ. of Scient. Instr.*, July 1940, Vol. 17, No. 7, pp. 182–186.)

4000. "Electrical Measurements and Measuring Instruments: Third Edition" [Book Review].—E. W. Golding. (*Elec. Review*, 30th Aug. 1940, Vol. 127, p. 167.)

SUBSIDIARY APPARATUS AND MATERIALS

4001. The Relationship between Certain Optical Parameters and Electrical and Geometrical Parameters of an Electrical Immersion Objective.—F. A. Savchenko. (*Journ. of Tech. Phys.* [in Russian], No. 24, Vol. 9, 1939, pp. 2211–2219.)

As an extension to the investigation by Johannson (296 of 1935 and back ref.) experiments were conducted to determine the effect of the separation *c* between the diaphragms (Fig. 1), the distance *b* between the cathode and the diaphragms, and the diameter *d* of the apertures, on the magnification and focal length of the system and on the size of the high-definition and low-definition areas of the image (Fig. 4). Experiments were also made, similar to those of Johannson, for determining the effect of voltages applied to the diaphragms on the optical properties of the system. The experiments and the apparatus used are described in detail and a number of experimental curves are shown. It is stated that on the basis of this investigation the electrical and geometrical parameters can be chosen to obtain the best possible results for a given set of requirements.

4002. New Electron Microscope developed at Camden [including Use of Very Thin Nitrocellulose Film to support Specimen].—Marton: R.C.A. (*Electronics*, May 1940, Vol. 13, No. 5, pp. 38 and 40.) *See* also 3545/6 of September.

4003. An Electron Microscope for the Research Laboratory.—Zworykin: R.C.A. (*Science*, 19th July 1940, Vol. 92, pp. 51–53.)

4004. Electron Microscope using an Electron Mirror [reducing Tube Length and using Some Stages Twice].—E. M. I. Laboratories. (*E. & Television & Short-Wave World*, June 1940, Vol. 13, No. 148, p. 250.)

4005. Electron - Microscope Fellowship established [under National Research Council, by R.C.A.: open to Microbiologists].—(*Sci. News Letter*, 10th Aug. 1940, Vol. 38, No. 6, p. 85.)

4006. Cathode-Ray Tube for High-Voltage Applications [Special Electrode-Supporting System].—(*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, p. 180.)

4007. A Cathode-Ray Alphabet Machine [tracing Letters by Manipulation of Switches: at present for Demonstration only].—Friend. (*Electronics*, June 1940, Vol. 13, No. 6, p. 40.)

4008. "The Hot-Cathode Low-Voltage Cathode-Ray Tube" [Book Review].—Mezger. (*Communications*, June 1940, Vol. 20, No. 6, p. 25.)

4009. An Indirectly-Heated Cathode for Cathode-Ray Tubes.—(*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, p. 223.)

4010. Oscillograph Camera [for the Model 3339 Oscillograph]. — Cossor Ltd. (*Journ. Scient. Instr.*, July 1940, Vol. 17, No. 7, p. 192.)

4011. Mounting of Getter in Cathode-Ray Tubes [particularly in the Modern Short-Neck Type].—(*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, p. 232.)

4012. Papers on White Luminescent Screens for Kinescopes.—Perkins: Leverenz. (*See* 3956.)

4013. A Mechanism for the Fluorescence of Alkaline-Earth Oxides.—Uehara & Takahasi. (In paper dealt with in 3863, above.) For the theory of ZnS phosphors *see* 3156 of August.

4014. Halation on Kinescope Screens [and Methods of Reduction].—Baker. (*See* 3955.)

4015. Phosphorescent Phosphors [particularly Modern Strontium-Sulphide Phosphors].—Levy & West. (*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, pp. 173–174 and 179.) Abstract of a recent lecture.

4016. Improved Materials for Fluorescent Screens [Advantages of Use of Selenide Component].—(*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, p. 236.)

4017. Deposition of Fluorescent Material on Thin Layer of Gold increases Image Brightness.—R.C.A. (*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, p. 224: paragraph only.)

4018. Applications of X-Ray Technique to Industrial Laboratory Problems [Fluorescent Screens, etc.].—Rooksby. (*G.E.C. Journ.*, Aug. 1940, Vol. 11, No. 2, pp. 83–95.)

4019. On the Use of Oiled Photographic Emulsions [for Fluorescent Sensitisation to Light or Charged Particles: Solvents for Rapid Removal].—Rogers. (*Journ. Opt. Soc. Am.*, July 1940, Vol. 30, No. 7, p. 316.)

4020. Materials for Vacuum Tube Manufacture.—Monack: R.C.A. (*Indust. & Eng. Chemistry*, Industrial Edition, 1st Aug. 1940, Vol. 32, No. 8, pp. 1028–1033.)

4021. The Construction and Cooling of Large Vapour Traps ["Winding Staircase" Baffle, etc: used in Evacuating a Porcelain-Steel Accelerating Tube].—Northrup & others. (*Review Scient. Instr.*, July 1940, Vol. 11, No. 7, pp. 207–210.)

4022. A Differential Liquid Manometer of High Sensitivity, founded on Pettersson's Theory of Submarine Waves.—Sederholm & Benedicks. (*Arkiv för Mat., Astron. och Fysik*, Stockholm, No. 8, Vol. 27A, 1940, pp. 1–5: in English.)

4023. "Modern Physical Laboratory Practice" [Book Review].—Strong & others. (*Journ. of Scient. Instr.*, Aug. 1940, Vol. 17, No. 8, p. 216.) *Cf.* 1241 of March.

4024. A Direct-Current and Audio-Frequency Amplifier [Linear Amplification of Voltages from a Few Microvolts to 30 Millivolts].—Black & Scott. (*See* 3898.)

4025. The Ionisation Time of Thyratrons [and Grid-Glow Tubes: C-R-O Measurements on Different Types: Time as Function of Grid Over-Voltage].—Harrison. (*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, pp. 160 and 163.) Summary of *A.I.E.E. Technical Paper* 39-116.

4026. The Self-Regulated Inverter in Push-Pull Connection [Theoretical Investigation of Action of D.C./A.C. Converter: Frequency dependent on Load: Possibilities of keeping Frequency Constant].—Brückner. (*Arch. f. Elektrot.*, 10th Jan. 1940, Vol. 34, No. 1, pp. 1–19.) For work on the externally-driven inverter *see* Ostendorf, 1166 of 1939.

4027. The Theory of Rectifier Circuits, with Special Reference to Harmonics in the Supply Circuit.—Satoh. (*Researches of Electrot. Lab.*, Tokyo, No. 434, 1940, 143 pp: Japanese with English synopsis.)

4028. Initial Reignition Voltage Measurements [and the Great Variation with Varying Arc Current].—Garbuny & Matthias. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, pp. 182–183.)

4029. Polarity Effects in the Reignition of High-Voltage A.C. Arcs.—Fukuda. (*Electrotech. Journ.*, Tokyo, June 1940, Vol. 4, No. 6, pp. 143–144.)

4030. The Mechanism of Electrical Discharges in Gases of Low Pressure [Survey, with 339 Literature References].—Druyvesteyn & Penning. (*Reviews of Mod. Physics*, April 1940, Vol. 12, No. 2, pp. 87–174.)

4031. Time-Lag Analysis of the Townsend Discharge in Argon with Activated Caesium Electrodes [Source of Lag is the Diffusion of Metastable Argon Atoms: etc.].—Engstrom & Huxford. (*Phys. Review*, 1st July 1940, Vol. 58, No. 1, pp. 67–77.)

4032. Spark Gaps with Short Time Lag [Use of Small Particles of Carborundum, etc., attached to Cathode].—Slepian & Berkey. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 210: summary only.)

4033. Spectroscopic Study on Ultra-High-Frequency Discharges [Ordinary H.F. Corona and "Torch" Discharge].—Asami & others. (*Electrotech. Journ.*, Tokyo, June 1940, Vol. 4, No. 6, pp. 141–142.)

4034. Papers on the Sparking Threshold in Air, and the Breakdown Potential for Sphere Gaps.—Haseltine: Meek. (*See* 3748 & 3749.)

4035. Breakdown Voltage Variation in Hydrogen [Lowering of Breakdown Voltage by Irradiation of Cathode cannot be completely explained by Metastable Conditions].—Fucks & Schumacher. (*Naturwiss.*, 16th Feb. 1940, Vol. 28, No. 7, p. 110.)

4036. The Lining of Metal Capillaries with Glass and the Application to a Capillary Positive Ion Source [Advantages for Electrical Gaseous Discharges].—Getting & Leighton. (*Review Scient. Instr.*, July 1940, Vol. 11, No. 7, pp. 232–234.)

4037. The Construction and Use of Selenium Rectifiers.—(*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, pp. 200–202.)

4038. A High-Voltage Stabiliser [for Voltages above 10 Kilovolts: Fraction of High Voltage is compensated by Battery and applied to Grid of Pentode whose Plate is connected to Grids of Two Gas-Triodes short-circuiting Resistances in Transformer Primary Circuit].—Alfvén & Eklund. (*Arkiv för Mat., Astron. och Fysik*, Stockholm, No. 6, Vol. 27B, 1940, pp. 1–3: in English.) The circuits given by Hunt & Hickman (1691 of 1939) are "not very convenient" for these voltages.

4039. A Voltage Regulator using Thermionic Valves [for controlling the Excitation of Synchronous Machines].—Ruberti. (*L'Elettrotec.*, 25th May 1940, Vol. 27, No. 10, pp. 239–242.)

4040. Voltage Control with a Non-Linear Wheatstone Bridge [with Two Incandescent Lamps].—Richter. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 20–21 and 108.)

4041. An Electronic Switch for Fluorescent Lamps [the "Glow-Switch," with Contacts actuated by Bimetal Strip heated by Glow Discharge].—Hays. (*Electronics*, May 1940, Vol. 13, No. 5, pp. 14–15.)

4042. A THERMISTOR VOLTAGE REGULATOR.—Green & Pearson. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, p. 204: summary only.) *See* also 3359 of September.

4043. VARISTORS: THEIR CHARACTERISTICS AND USES.—Becker. (*See* 3773.)

4044. THE CHARACTERISTICS OF CONTACTS.—Sotskov. (*Automatics & Telemechanics* [in Russian], No. 6, 1939, pp. 29–44.)

Methods are indicated for plotting characteristics showing the relationship between the maximum permissible voltage and current values in the contact circuit of a relay. Conditions determining these values, and various factors affecting the life of contacts, are discussed.

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4151. Criticisms of Paper on Electronic Control Gear for Welding.—(*E. & Television & Short-Wave World*, May 1940, Vol. 13, No. 147, p. 238.) *See* 2816 of July.

4152. Welding-Period Timing by means of Steel Ignitrons.—Higgins. (*E. & Television & Short-Wave World*, June 1940, Vol. 13, No. 148, pp. 251–253.)

4153. The Lagometer [Instrument on Condenser-Charging Principle for Time Measurements].—Bryan. (*Sci. Abstracts*, 25th July 1940, Vol. 43, No. 511, p. 310.)

4154. An Electronic Timer [for Bromide Printing, etc : on Condenser Time-Delay Principle].—Norton. (*E. & Television & Short-Wave World*, April 1940, Vol. 13, No. 146, p. 175 : summary only.)

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For a note stressing the value of this instrument in accelerating the inspection of metals & alloys in a defence programme, see *Science*, 26th July 1940, Supp. p. 6.

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4161. An Optical Smoothness-Meter for Evaluating the Surface Finish of Metals [using Small Integrating Sphere and Rectifier-Type Photocell].—Guild. (*Journ. of Scient. Instr.*, July 1940, Vol. 17, No. 7, pp. 178–182.)

4162. Photoelectric Relay for Control of Smoke from Boiler Flues.—Ray. (*Sci. & Culture*, Calcutta, June 1940, Vol. 5, No. 12, pp. 749–750.)

4163. Phototube inspects Steel Strips for Pinholes [with Strip moving at 1000 ft/min.].—Westinghouse. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 60 and 62.) *Cf.* 2182 of 1939.

4164. R.C.A. Phototube Reference Chart.—R.C.A. (*Electronics*, June 1940, Vol. 13, No. 6, p. 73.)

4165. "Photoelectric and Selenium Cells: Second Edition" [including Industrial Applications: Book Review].—Fielding. (*Wireless Engineer*, Sept. 1940, Vol. 17, No. 204, p. 398.)

4166. Electronic Counting Circuits [for Mass Production Processes, etc: a Survey].—(*E. & Television & Short-Wave World*, June 1940, Vol. 13, No. 148, pp. 261–263.)

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4168. Photocell Multiplier Tubes [Useful whenever Low Light Level or Large Frequency Range is involved].—Larson & Salinger. (*See* 3964.)

4169. Further Applications of Space-Charge Coupling [to Condenser-Microphone Amplification, Ultra-Micrometer Circuits, etc.].—Sargrove. (*See* 3760.)

4170. A Magnetic Ultra-Micrometer for Measurement of Thin Films of Non-Magnetic Material superposed on a Base of Magnetic Material [detecting 10^{-6} Inch of Film: No Amplification].—Ellwood. (*Phys. Review*, 15th July 1940, Ser. 2, Vol. 58, No. 2, pp. 204–205: summary only.)

4171. A Convenient Electrical Micrometer and Its Use in Mechanical Measurements.—Gunn. (*Journ. of App. Mechanics*, June 1940, Vol. 7, No. 2, pp. 49–52.) The full paper mentioned in 3686 of September.

4172. The Micro-Analysis of Gases by Physical Methods.—Ransley. (*See* 3883.)

4173. Vacuum Tubes in Chemical Research.—Penther & Pompeo. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, p. 284: summary only.)

4174. The Measurement of the Rheological [Flow & Deformation] Properties of Some Industrial Materials [Survey].—Scott Blair. (*Journ. of Scient. Instr.*, July 1940, Vol. 17, No. 7, pp. 169–177.)

4175. Stress Measurement by Magnetostriction.—Smith & Luxford. (*Sci. Abstracts*, Sec. B, 25th June 1940, Vol. 43, No. 510, p. 273.)

4176. The Admiralty Cathode-Ray-Oscillograph Engine Indicator [with Electro-Magnetic Pick-Up].—Smith, Lakey, & Morgan. (*Sci. Abstracts*, Sec. B, 25th June 1940, Vol. 43, No. 510, p. 270.) Smith's paper on the basic principles in the design of c-r-o indicators is dealt with on the same page.

4177. Measurements of Noise and Vibration [including New Developments in Apparatus].—Scott. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 284–285: summary only.)

4178. An Electronic Fire Detector [of High Sensitivity, based on Production of Langevin Ions: Electrostatic Relay controlled by Comparative Conductivity of Ambient Air and Sealed Rare Gas (both Permanently Ionised by Radioactive Layers)].—(*E. & Television & Short-Wave World*, July 1940, Vol. 13, No. 149, p. 310.) Developed in Switzerland.

4179. Radio for Parachute Fire-Fighters [Ultra-Short-Wave "All-Dry" Transceiver weighing Six Pounds].—(*Communications*, July 1940, Vol. 20, No. 7, p. 13.)

4180. "Lehrbuch der Hochfrequenztechnik" [Second Edition].—Vilbig. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 68 and 70.) A separate volume, the Bibliography, is also reviewed, and is criticised for the lack of British and American references.

4181. "Introduction to Chemical Physics" [Book Review].—Slater. (*Electronics*, June 1940, Vol. 13, No. 6, pp. 64..68.) An enthusiastic review by D. B. Langmuir.

4182. "Modern Physical Laboratory Practice" [Book Review].—Strong & others. (*Journ. of Scient. Instr.*, Aug. 1940, Vol. 17, No. 8, p. 216.) *Cf.* 1241 of March.

4183. "The 'Radio' Handbook" [Book Review].—Staff of *Radio*. (*Proc. Inst. Rad. Eng.*, June 1940, Vol. 28, No. 6, pp. 287–288.)

4184. "Radio's Master Encyclopedia" [Directory, Catalogues, etc: Book Review].—(*Communications*, July 1940, Vol. 20, No. 7, p. 20.)

4185. "Telephony: Supplement to Volume 2" [Selector Circuits and Unit Automatic Exchanges: Book Review].—Herbert & Proctor. (*Wireless Engineer*, Sept. 1940, Vol. 17, No. 204, p. 397.)

4186. The Case History of a Scientific News Story.—Simpson. (*Science*, 16th Aug. 1940, Vol. 92, pp. 148–150.) "Fairly typical of what still happens to scientific news."

4187. Lucite Instrument Cases [Pioneer Applications of the Methyl Methacrylate Transparent Plastic].—(*Journ. Franklin Inst.*, Aug. 1940, Vol. 230, No. 2, pp. 276–277.)

4188. Carrier Telemetering with the Metameter [Impulse-Duration Telemeter].—Lunge. (*Gen. Elec. Review*, Aug. 1940, Vol. 43, No. 8, pp. 336–343.) *See* also 1716 of April.